Effects of Ability Grouping on Students' Game Performance, Physical Activity, and Movement Patterns

by

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Abstract

Research has supported the use of within-class ability grouping in the classroom setting. However, little research has been completed in regards to the use and effectiveness of ability grouping in the physical education classroom setting. Therefore, the purposes of this study were to (1) examine ability groupings effects on students rate of play, (2) compare students' performance scores from match skill play to mixed skill play, (3) to determine if students movement patterns differ when grouped based on skill, (4) to determine if students physical activity levels differ when in mixed skill compared to matched skilled games, and (5) to determine if ability grouping outperform traditional mixed skill grouping in terms of opportunity to respond, performance scores, increasing more game appropriate movement patterns, and increasing moderate to vigorous physical activity (MVPA) levels. The participants in this study were forty-eight, fifth graders from three classes. Each student competed in four matched skill games where they competed with and against similar skilled students. Additionally, students competed in four mixed skill games where students competed with and against an equal number of higher-skilled and lower-skilled students. The total numbers of games played across the three classes was forty- eight with each game lasting five minutes. All games were recorded and coded post hoc. Included in the coding were game performance variable, MVPA, and movement patterns.

Results indicated that lower-skilled students are at a disadvantage when competing in mixed-skill games, particularly as it related to performance variables. Lower-skilled students saw higher rates of success, rates of play, and greater performance scores during match skill game play. In contrast, higher-skilled students experienced greater rates of success, rates of play, and increased performance scores during mixed-skill games. However, both higher and lower skilled students suffered in terms of MVPA when competing in mixed skill play. Finally, as it relates to movement patterns, it appears that lower-skilled student patterns change during mixed-skill games to cover more area. While higher-skilled students movement patterns are reduced likely during mixed-skill games. Together these results indicate positive benefits for both higher and lower-skill students competing in match skilled games. Furthermore, these findings suggest that ability grouping in physical education can potentially enhance students' game performance, increase opportunity to respond, alter movement patterns, and increase MVPA.

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CHAPTER 1

INTRODUCTION

According to the Society of Health and Physical Education, the goal of physical education is to "develop physically literate individuals who have the knowledge, skills and confidence to enjoy a lifetime of healthful physical activity" (SHAPE America & Human Kinetics, 2014). In an attempt to reach this goal, teachers implement game-based instruction. During game-based instruction, students typically compete in small sided games with the intention that students will be able to transfer knowledge gained from lead up games to a full size game.

Game play within physical education, however, is not necessarily a level playing field, with lower-skilled players often being excluded from game play opportunities. For example a higher-skilled students might not pass to a lower-skilled student during a game of ultimate Frisbee because if the lower-skilled student doesn't catch the Frisbee the team loses possession. Similar to the previous example, if lower-skilled students are denied opportunities to respond, it is likely that they will not improve. This in turn, has the potential for these students becoming disengaged and therefore less likely to attain a lifetime of healthful physical activity (Robinson et al., 2015).

Knowing that lower-skilled students are at a disadvantage during, mixed-skilled games should help promote researchers and teachers to find a method that promotes improvement for all students. Similar to the famous story of *Goldilocks and the Three Bears*, where Goldilocks sought to find the chair, porridge, and bed that were "just right," researchers and teachers should seek to find the learning environment that is not too difficult and not to easy but “just right” for students. Nonetheless, there is a dearth of research in physical education that specifically addresses pedagogies of equality, at least from a quantitative perspective.

Historically, ability grouping has sought to provide learning opportunities for higher and lower-skilled students by placing them into groups with similar skilled peers (Steenbergen-Hu, Makel, & Olszewski-Kubilius 2016). Despite the intention to match student capacities to the level of academic demands, ability grouping has been a controversial topic with suggestions that it can lead to racial, and social economical discrimination in which minority and poor students suffer (Worthy, 2010). It must be pointed out, however, that these results were the outcomes of ability groups lasting the duration of a school year or longer. More recent methods of ability grouping have taken a different approach called “within-class grouping.” This form of separation consists of grouping students based on ability for a shorter duration, and may last for only one class or for the length of a unit. It is also important to note that students may belong to different abilities groupings across subject areas.

Research on within-class ability grouping on students overall academic achievement has been found to produce positive, moderate, and statistically significant outcomes in math, reading, science and social studies courses (Steenbergen-Hu, Makel, & Olszewski-Kubilius 2016). The number of studies that have examined ability grouping in the physical education contexts are, nonetheless, considerably fewer. In the study of Hastie, Ward, and Brock (2016), lower-skilled elementary school students who participated in mixed-skill teams during a unit of handball suffered in terms of ball engagement and success rates. Outside of within-game opportunities, a number of studies have shown differential improvement rates of students of differing skill levels across longer interventions. Furthermore in (Mahedero, Calderón, Arias-estero, Hastie, & Guarino, 2015) the highest skilled students and the lowest skilled students had a sigmoidal relationship of skill, knowledge, and decision making improvement. That is, lower-skilled students and higher-skilled students did not show the same rate of improvement as their middle skilled peers, indicating that the level of difficulty for students to learn may have been too great for the lower-skilled students and insufficient for the higher-skilled students.

In order to examine the effect of ability grouping of young students' game performance, the theoretical basis for this study was dynamical systems theory. Moreover, nonlinear-pedagogy originates from dynamical systems theory and applies the theories findings to physical education and coaching. To gain a greater understanding of dynamical systems theory, three components will be examined. These are affordances, constraints, and nonlinear-pedagogy.

Physical education classrooms can be thought of as a dynamic system with a wide variety of affordances (i.e., opportunities for action) available to students. Students' abilities to make sense of relevant sources of information during game play and practice differ from individual to individual. For example, during a game of basketball an advanced student might be aware of the affordance that is offered from a student cutting to the basket and make a pass to the cutting player. However, a lower-skilled player in that same scenario may be too focused on dribbling the ball to notice the affordance offered by the cutting player. Given the skill levels of the students in the above example, one could justify how separating students into games with other similar skilled students might be beneficial.

Under a dynamical systems theory perspective, constraining the environment that students are placed in by grouping students based on ability may enhance their ability to attune to the affordances provided to them. For example, according to the constraints-led approach, skill acquisition is a process of self-organization based around the three forms of constraints (i.e., performer, environment, task) interacting on the student (Chow, 2013). Placing a student in an environment that is developmentally appropriate for them can enhance skill acquisition.

When conceptualizing the plethora of affordances as “noise”, it can be seen that the volume of the affordance occurring during a mixed-skill game might be too great for lower-skilled players while it might be to minimal for higher-skilled players. Using ability grouping allows for a better modulation of the noise so that it can be turned down to a developmentally appropriate level for lower-skilled peers and turned up for higher-skilled players when competing in matched skilled games. This may generate the “just right zone” that has the potential to meet students’ needs. Furthermore, from a nonlinear-pedagogy perspective, the manipulation of constraints can lead to opportunities to explore functional movement patterns and behaviors that can increase success in game play. This was seen in Hastie, Ward and Brock’s (2016) findings that showed lower-skill students competing in matched skill games improved and performed better than their lower-skilled peers competing in mixed-skill games.

The current study sought to extend the findings of Hastie, Ward, and Brock (2016) using a stronger design where students were used as their own control. In this design a more definitive answer could be derived from separating students based on ability. Moreover, by having each student act as their own control it allows for a more sophisticated analysis. In addition to this change of design, the current study sought to examine the effects of ability grouping on a number of other significant dependent variables as they relate to game play in physical education. These included students' movement patterns through the field of play, as well as the extent to which they were engaged in moderate-to-vigorous physical activity (MVPA).

The specific research questions posed in this study include:

1. Does placing students into homogeneous groups (i.e., lower- and higher-skilled) increase ball performance engagement for both groups of students?
2. Does homogeneous grouping lead to different rates of success than heterogeneous grouping for both higher- and lower-skilled players?
3. Does homogeneous grouping lead to different performance scores than heterogeneous grouping for both higher- and lower-skilled players?
4. Do students' have different movement patterns during game play when in homogeneous or heterogeneous groups?
5. Do students' physical activity levels differ during game play in homogeneous and heterogeneous groups?
6. Does homogeneous ability grouping in physical education outperform traditional heterogeneous grouping in terms of ball engagement rates, percent success, performance scores, generating more game appropriate movement patterns, and increasing MVPA levels?

CHAPTER II

REVIEW OF LITERATURE

Dynamical systems theory conceptualizes the nature of phenomena in regards to patterns of change or process. There are many components associated with dynamical systems theory when applied to movement and sports. Some of these components include: constraints, ecological dynamics, affordances, and non-linear pedagogy. In order to understand these terms and subsequent complex relationships, definitions have been provided in Table 1. Further detail will be provided throughout the paper on the various components of dynamical systems theory and their application to physical education.

Table 2.1
Dynamical Systems Theory Terms and Definitions

Terms	Definitions
Dynamical systems theory	Dynamical systems theory, applied to the study of movement, has emerged as a framework for illustrating athletic performance from the process of coordination, and control in movement by which patterns emerge through processes of self-organization (Davids, Araujo, & Shuttleworth, 2005; Davids, Glazier, Araújo, & Bartlett, 2003; Ganter, Witte, & Edelmann-Nusser, 2011).
Constraints	Constraints are considered internal or external boundaries which can enhance or limit an individual's behavior (Clark, 1995; Newell, 1986; Renshaw et al., 2015; Renshaw, Chow, Davids, Hammond, & Chow, 2010)
Constraints-led approach	According to the constraints–led approach, skill acquisition is a process of self-organization based around the various constraints (i.e., performer, environment, task) interacting on the system (Chow, 2013; Renshaw, Davids, Shuttleworth, & Chow, 2009; Renshaw et al., 2010).
Nonlinear-pedagogy	Is based on the concepts of dynamical principals and that through manipulation of task constraints, during practice, provides participants opportunities to explore functional movement patterns and behaviors

	that can increase success in game play (Chow, Davids, Button, Renshaw, & Shuttleworth, 2008; Chow, Davids, Button, Shuttleworth, & Renshaw, 2007; Wolpert, Ghahramani, & Flanagan, 2001).
Explicit instructions	Instructions that are directed at conscious control that direct specific movement solutions (i.e., jump high, run faster) (Chow et al., 2008; Wolpert et al., 2001).
Implicit instructions	Instructions that guide exploration of movement solutions (i.e., imagine the flight pattern the basketball will travel during the shot) (Chow et al., 2008, 2007; Wolpert et al., 2001).
Transfer	Refers to the ability of utilizing what was learned in training and applying it to a competitive setting (Chow, 2013; Vilar et al., 2014)
Affordances	Are opportunities for action that are provided as a result of objects, the environment, and people within the environment (Fajen, Riley, & Turvey, 2009; Gibson, 1966; Hristovski, Davids, Araújo, & Passos, 2011).
Prospective control	Refers to the ability of athletes to alter their behaviors in advanced based on the constraints of the system (Araújo, Davids, & Hristovski, 2006; Fajen et al., 2009).
Information movement coupling	Essentially, the idea of adjusting ones' movements based on the information provided by the environment (Davids, Kingsbury, Bennett, & Handford, 2001).
Task simplification	Refers to the process of creating representative tasks by using small playing fields and scaling down equipment with the intent to increase information-movement coupling
Ecological dynamics	Takes into account the various types of constraints (i.e., performer, environment, and task)
Body scaling	When an individual perceives the affordance an object will allow based on their body size as well as the size of the object (Haywood & Getchell, 2014).
Self-organization	The ability of a person to adapt to meet the needs of a variety of movement systems (Chow, Davids, Hristovski, Araújo, & Passos, 2011; Kelso, 1995).
Attunement	One's ability to make sense of the relevant sources of information to form successful movement patterns.

Dynamical Systems Theory

The components of dynamical systems theory have been applied to mathematics, physics, biology, psychology, chemistry, and kinesiology, making it a multidisciplinary approach (Davids et al., 2003). Dynamical systems theory is used to describe systems that are constantly changing over time. In dynamical systems, an input will usually result in a specific output (Davids et al., 2003). Throughout this paper the sport of basketball will be used to demonstrate how inputs result in outputs. When applying dynamical systems theory to a sports and physical education context, it is important to understand that movement systems (i.e., humans) can be thought of as a dynamical system with many degrees of freedom that can act on the environment (Renshaw et al., 2010).

For example, a person is afforded the opportunity to run, jump, swing their arms, and perform a plethora of other movements to act on their environment. As more items and movement systems are introduced into the system, new affordances become available which result in either an increase or decrease in the degrees of freedom. For example, a basketball offers the affordance of dribbling and passing, therefore increasing the degrees of freedom. On the other hand, affordances aren't equal, meaning that an item or object that affords one person an opportunity may not afford another person the same opportunity. For some people, a basketball hoop offers the affordance of dunking, due to their body dimensions and abilities, while others may not be offered this affordance despite using the same hoop. As noted by, Konczak (1990), people estimate action possibilities based on their body dimension and abilities. Through the use of body scaling, an individual can perceive what affordances are available to them (i.e., based on my height and abilities, I can dunk the basketball on this hoop).

It was noted by Passos, Araújo, Davids, and Shuttleworth (2008), that a complex dynamical system begins to emerge when students behaviors are influenced by others. Therefore, different movement systems may alter the degrees of freedom for other movement systems. Applying this concept to a sports application can be observed when an offensive player attempts to get open for a pass, resulting in the defense altering their positions in an attempt to counteract the offense. As the defense adjusts, it reduces the degrees of freedom available to the offense. In other words, players' behaviors are constantly being altered based on other players' behavioral patterns.

Another component of dynamical systems involves perception and behavior, specifically altering behaviors based on previous experiences known as prospective control (Araújo et al., 2006). For example, the behavior of an offensive player getting blocked by a larger player while attempting a lay-up may result in a change of the offensive player's future decisions. Knowing that he was blocked before, it is likely he will not attempt another lay-up in a similar situation but rather adjust his movement to avoid getting blocked again. These interactions between players highlight the emergence of information-movement coupling which is essentially how the behavior of a single player results in the alteration of behavior for another (Davids et al., 2001). As listed in the example above, as the player adjusts to avoid getting blocked, this adjustment results in new movement possibilities for the other players. One of the most predominant topics in dynamical systems is the notion of constraints, and the effects they have in increasing or reducing variability.

Constraints

Constraints have been defined as boundaries which enhance or limit behaviors for a learner seeking a stable state (Clark, 1995; Newell, 1986). When applying this to sports and physical education the interaction of various constraints shapes the way an individual learns a stable movement pattern (Renshaw et al., 2010). Additionally, as noted by Passos, and colleagues (2008), constraints play a role in the development of movement patterns, and the decision making process. In order to better understand how constraints can shape movement patterns, cognition, and decision making, it is important to know the classification of constraints. Newell (1986) highlighted three classifications of constraints, which will be discussed in further detail below.

The first classification of constraints proposed by Newell (1986) is known as performer constraint. This form of constraint consists of a person’s individual-related factors and can be split up into two categories; structural and functional (Haywood & Getchell, 2014). Performer constraints that are categorized as structural include factors such as an individual’s height, weight, strength, and muscle mass. Examples of the functional category include motivation, fear, and attentional focus. Performer constraints generate different affordances unique to the individual’s characteristics, and therefore plays a role in determining the performance style utilized by an individual (Renshaw et al., 2010). As highlighted in Renshaw et al. (2010), basketball players adjust their playing style based on their unique performer constraints, with shorter players more likely to take shots further away from the basketball hoop and taller players staying near the basket for scoring opportunities and rebounds. This example illustrates the possibility of a simultaneous interplay of structural and functional constraints. In this example, the reason behind the shorter player taking shots further away from the hoop could be a combination of his structural constraint of being short, and the functional constraint of fear (i.e., of getting blocked). Therefore, the combination of an individual's structural and functional constraints can determine the way a player seeks a successful movement pattern. With this in mind, it becomes clear that movement solutions will vary based on a learner's personal constraints.

The second classification of constraints described by Newell (1986) is environmental constraint. This classification can be further broken down into two classifications: physical and social. Physical factors are constraints that are in the student's learning environment. Some examples of physical factors include gravity, altitude, light, and noise. For example, players competing at a high attitude are constrained by the lower partial pressure and therefore receives less oxygen. Furthermore, a baseball player could be constrained by the sun or lights in their eyes. The second factor of environmental constraints is social constraints, which are the results of the influences by peers, social expectations, teachers, coaches and parents. Social factors are particularly important for young learners. This can be observed by the strong influence parents have in selecting activities that their children participate in (Renshaw et al., 2010). For example, a child with two parents that played golf at the collegiate level will likely be exposed to golf at a much earlier age than most children. Therefore, social constraints would likely have a strong influence on the child.

The third classification of constraints is known as task constraint (Newell, 1986). Task constraints are made up of equipment and implements used (i.e., basketballs, shoes, rackets, etc.), as well as the rules and goals of the task. Renshaw and colleagues (2010) argue that task constraints are perhaps the most significant form of constraints for teachers and coaches. This is due to the ability that coaches and teachers have to alter task constraints. For example, as much as basketball coaches would like to alter performer constraints by making their players taller, they have no control over this. Pertaining to environmental constraints, players can reduce the level of light by using sunglasses, but can't alter the effects of gravity. However, through manipulation of task constraints, teachers and coaches can provide boundaries which allow students to explore movement solutions for a desired task (Chow et al., 2007; Pinder, Renshaw, & Davids, 2009). This exploration may lead to optimal movement solutions that meet the task goals. However, before coaches and teachers can utilize task constraints, they must have an understanding of how they work.

Constraints-led Approach

The constraint-led approach highlights how behaviors can emerge as a result of the performer, environment, and task constraints. Furthermore, the constraints-led approach states that constraints constantly influence one another, which fuels change in behavior (Chow, 2013; Renshaw et al., 2010). These interactions can act as rate limiters, by holding back the emergence of some skills, while promoting the development of others. Uehara, Button, Falcous, and Davids (2014) suggested from a dynamical system theory perspective, improvement in sports emerges due to the interaction of multiple constraints. The example of the short basketball player who is experiencing the functional constraint of fear demonstrates this notion. His fear of being blocked is acting as a rate limiter toward the development of shooting a lay-up. Alternatively, the fear of being blocked is also promoting the development of shooting from a distance, which is completing the task goal of scoring during the game of basketball. With this in mind, motor learning can be thought of as a process of exploring movement patterns to meet the demands of the various constraints (Renshaw, Davids, Shuttleworth, & Chow, 2009). However, it is important to note that a constraints-led approach focuses on the understanding of how the manipulation of constraints lead to changes in behaviors and does not provide a means for creating motor learning programs (Chow, 2013).

Ecological dynamics

Ecological dynamics uses concepts and principals of dynamical systems to understand the decisions that occur as a result of the continuous interactions between the performer and the environment (Brymer & Davids, 2013; Travassos et al., 2012) While the constraints-led approach focuses on how manipulating constraints results in action, ecological dynamics focuses on perceptions and behaviors that result in movement. Moreover, the ecological dynamics approach provides insight into the decision making process of an athlete, and how environmental and task constraints shape this process (Araújo et al., 2006). This approach implies that as a person moves within their environment, opportunities of action persist, emerge, and dissolve. The performer-environment relationship provides insight into the performer's ability to identify and respond to affordances in the process of skill acquisition. To gain a better understanding of ecological dynamics, it is important to cover the topic of affordances.

Affordances

The concept of affordance was originally used to describe opportunities for actions provided to animals by the environment (Gibson, 1966). An environment may afford a plethora of action opportunities. In the physical education context, an affordance can be thought of as opportunity for action during practice or game play (Fajen et al., 2009). For example, when considering a basketball court as an environment, the court affords jumping, running, standing. Even the ball affords multiple actions such as dribbling, shooting, and passing. Additionally, players afford opportunities for one another, which are known as social affordances. Social affordances have been classified into the following three forms: for another, joint action, and of another (Baron & Boudreau, 1987; Fajen et al., 2009). The first classification, affordances for another, are the perceptions of what another player can or cannot do. For example, a high skill basketball player may perceive a low skill player on his team as unable to catch his pass. Moreover, a player may perceive an opponent as too short to block a shot. The second classification of social affordances is joint action affordances. These types of affordance are made up of what the perceiver and another player can perform through cooperation. An example of this can be observed during a give-and-go pass, where team members penetrate the defense through a coordinated action. The final classification of social affordances has been labeled: affordances of another person. This can be observed when an offensive player takes advantage of an opponent's weakness. For example, a player knows an opponent is slower and therefore perceived that the opponent's performer constraint affords an opportunity to attempt a shot. Affordances in game play can be thought of as dynamic, with opportunities for actions constantly changing, and some dissipating quicker than others. For example, the affordances that occur during a fast break don't last long due to the changing rush of offensive and defensive players (Fajen et al., 2009).

Nonlinear pedagogy

The notion that humans can be classified as dynamical systems has led to the development of nonlinear pedagogy (Davids, Araújo, Hristovski, Passos, & Chow, 2012). Nonlinear pedagogy is founded on the concepts and principals of ecological psychology and dynamical systems theory. Nonlinear pedagogy has been defined as the application of the concepts and tools of nonlinear dynamics as they are applied to teaching in physical education and coaching practice (Chow et al., 2006; Renshaw et al., 2010). The principals of nonlinear pedagogy recognizes the need to create practice sessions that replicate the environment of game play as a means of promoting transfer from practice to competition (Chow, 2013; Vilar et al., 2014). Furthermore, practice sessions should allow learners to seek unique performance solutions based on their personal performer constraints (Passos et al., 2008). Therefore, the principals of the constraints-led approach can strengthen nonlinear pedagogy. Specifically, using constraints as a means to attune students to possible affordances to meet a movement goal. For example, a teacher that seeks to have students work on passing could restrict the area of the playing field and reduce the number of players to apply constraints. This would generate an environment in which students have a better opportunity to work on the main goal of improved passing, while still playing in a dynamical system representative of game play.

The nonlinear pedagogy approach to learning contradicts the common practices of teaching and coaching skills. Many coaches and teachers seek to mitigate variability in practice in the hopes of automatizing performances. For example, having students perform repetitive skills and drills unopposed. These forms of practice are not representative of game play scenarios that typically have high variability. To conceptualize this, picture a single student dribbling a basketball ball and weaving in and out of a straight line of cones. Drills like this poorly represent a game scenario and therefore prevent information-movement coupling from taking place during the learning process (Davids et al., 2001). Now picture this same student trying to penetrate a defensive press during a three-on-three game where the goal is to advance the basketball to the opposing teams' key. This drill would create more variability for the player, while still highlighting the need to work on dribbling and passing to advance the ball.

Similar to designing drills that mitigate variability, many coaches tend to stress one ideal form of a skill. This form of teaching has been described as a "one-size-fits-all" method where everyone should strive for the same form, regardless of their individual differences (Davids, Bennett, & Newell, 2006). An interesting example that displays both variability and the one-size-fits-all standards is the free throw in the game of basketball. When shooting a free throw, players are allowed variability leading up to the shot as a means to establish their own individual ritual. However, the shot itself is believed by most coaches and teachers to have one ideal form that everyone should strive for. This is in despite of one of the greatest free throw shooters in professional basketball history; Rick Barry, who shot free throws "granny style". In fact, Barry is still considered one of the greatest free throw shooters all-time in NBA with an impressive 90% of his free throws made over the span of his career (Lonsdale & Tam, 2008). The assumption that there is only one ideal form for a skill doesn't take into consideration individuals' performer constraints, and often hampers individual exploration of movement solutions.

Another component that sets nonlinear pedagogy apart is how instructions are given. Traditionally coaches and teachers provide explicit instructions (i.e., elbow at 90 degrees, follow through, etc.), which directs the process to a conscious level (Renshaw et al., 2009). However, this form of thinking has been found to be less efficient and may lead to failure as a performer reverts back to analyzing their movement process (Beek, Jacobs, Daffertshofer, & Huys, 2003). Instructions given in non-linear pedagogy are implicit, and instruct performers to visualize the movement outcome to allow the performer to explore a variety of movement strategies (Chow et al., 2008). Additionally, a coach or teacher could check for understanding by asking a performer which strategies worked and which did not. Based on these responses, the coach or teacher could manipulate constraints to help performers attune to the desirable affordances.

Non-linear pedagogy recognizes that learners are different, and should therefore be given the opportunity to explore movement patterns as a means to acquire movement solutions based on their individual needs. By fully understanding the constraints-led approach and how different constraints influence one another, teachers and coaches can utilize the principals of non-linear pedagogy. Through non-linear pedagogy, representative games can be developed to aide in the learning process that students will use in a real performance context (Chow, 2013). Therefore, the goal of students in non-linear pedagogy is to learn personal movement solutions that satisfy the constraints acting on them at any given time (Chow et al., 2011).

Research on Constraints in Physical Education

Constraints act as boundaries that can change the affordances available to a performer. Therefore, research on constraints in sports and physical education has focused on the results that emerge through the manipulation of constraints. Research on constraints in the coaching and physical education context has focused on the following areas: playing rules, field size, item scaling, and differences based on skill level. These four areas will be covered in greater detail below.

Playing Rules

Almeida, Ferreira, and Volossovitch (2012) found that manipulating playing rules during small sided games (SSG) of soccer had a significant impact on offensive performance (i.e., passing, shooting, time of possession). The eight U-13 male soccer players that participated in the study had nearly four years of experience, and played on a club team at the regional level. Due to these players' experience, they would likely be classified as elite and sub-elite players. The participants played in three different SSG types lasting ten minutes on a 40 by 30 meter wide field. The three game types were: (1) free-form; which consisted of standard soccer rules on the smaller field, (2) two-touches; which only allowed players to make two consecutive touches before they had to pass or shoot, and (3) four-passes; a game in which players had to complete at least four consecutive passes before they could shoot. Results indicated that players performed a greater number of shots in free-form and two-touches games than they did in the four-pass game. However, the rate of success, time of possession and number of passes were higher in the four-passes to score game. The findings indicate that manipulating constraints can lead students and athletes to ideal intended outcomes. For example, a coach that is seeking to improve a team's ball movement and time of possession during game play could benefit from implementation a four-pass game.

Serra-Olivares, González-Víllora, and García-López (2015) examined the effects of stressed attacking of the goal and its influence on youth soccer players by comparing two different SSG types. The first game type was similar to a standard game of soccer with the exception of involving no goalkeepers. The second game type followed similar rules as the first game type, with the addition of 4 goals on each side of the field. In each condition, players attempted to score as many goals as possible during the 8-minute 3 vs. 3 games played on a 20 by 30 meter field. Players were twenty-one U9 skilled soccer players that had at least one year of prior experience. Players were selected as participants in this study due to their classification as the best players of their respective teams. Data were collected for decision making and tactical performance using the Game Performance Evaluation Tool (GPET). Results indicated that participants' tactical performance for keeping possession of the ball and advancing toward the goal were better in the first SSG format, which was a closer replication of a standard soccer game, than the SSG that added additional goals. The authors concluded that adding more goals did not provide an accurate representation of soccer, where players have to work as a unit to advance the ball forward and get into a position where a shot can be attempted. When implementing constraints, teachers and coaches must be careful about considering the desired outcomes. For example, if a teacher wanted students to work on keeping possession and advancing the ball in a game of soccer, constraints similar to the ones used by Almeida and colleagues (2012) should be implemented to stress those elements.

Travassos, Duarte, Vilar, Davids, and Araújo (2012) analyzed how the number of possible passing opportunities affected passing speed and accuracy. Participants included eight male futsal players with an average age of 26 years old, who played on a competitive third division team. Participants were split into two groups of four and arranged to form a 5 by 5 meter square, with one person in each corner with two futsal balls in each square. For the first condition, players were instructed to simply pass back and forth to the person in front of them. In the second condition, players were instructed to pass the ball back and forth to the player diagonal to them. The third condition was a combination of the first and second condition, with the players receiving instruction to only pass to the player in front of them or diagonal to them depending on who did not already have a ball. In the fourth condition, players were able to pass to any player, so long as they did not already possess a ball. Finally, players competed in a 4 vs. 4 game of futsal. All games and conditions were recorded and analyzed post hoc using the position tracking software, (TACTO). Results indicated that as the conditions complexity increase, passing speed and accuracy decreased. Furthermore, the fourth passing conditions and game play had similar accuracy scores. These results imply that having higher levels of relevant variability built into tasks provides a better replication of game play. These findings support the claims that practice conditions should aim to replicate elements of game play to encourage the development of adaptive decision making behaviors needed in the dynamic system of game play (Araújo, Davids, & Passos, 2007). By manipulating constraints, teachers and coaches can target specific game skills (i.e., passing, defense, shooting) to work on, while still replicating game play.

Number of players

Tallir, Philippaerts, Valcke, Musch, and Lenoir (2012) sought to compare the amount of learning opportunities in a 3-on-3 basketball game compared to the standard

5-on-5 games. Participants were made up of forty-two 11 to 12 year old basketball players, with only the thirty best players' data being analyzed. Students were ranked by their coaches, and matched to play against players that were classified as the same ability level in order to help control student ability levels. Students played in four 5-minute games for each condition, with data being collected by video and analyzed post hoc using the coding instrument from Tallir, Lenoir, Valcke, and Musch (2007). Results indicated that participants experienced more learning opportunities during the 3-on-3 basketball games than during the 5-on-5 games. A similar finding was reported by Fenoglio (2003), which compared learning opportunities during 4-on-4 vs. 8-on-8 soccer games amongst advanced eight year olds. Results found that players had 585 more passing opportunities, 481 more scoring attempts, 301 more goals, and 525 more one-on-one opportunities during the 4-on-4 SSG. These findings taken together highlight how manipulating the number of players, may lead to an increase in learning opportunities for students.

Similar to Fengoglio (2003) and Tallir et al. (2012), Pill and Elliott (2015) compared a SSG game version of 12 per side Australian football to the standard 18 per side Australian football. Players were elite U14 Australian footballers that were recommended for the study by coaches that deemed them the best players in the local area. Players participated in eight 18-minute game play sessions for each condition, generating a total of 18 games for data collections. Games were filmed and later coded by tallying up events using the DartFish Easy tag application. The researchers found that the combination of playing on a smaller sized field with less players resulted in more scoring plays and opportunities. Additionally, the limited number and field size increased student involvement due to the reduced space per player.

Vilar et al. (2014) investigated the effects of altering the number of players during SSG, in order to better understand how manipulating the number of players would affect player actions. Specifically, they examined the opportunities for offensive players to maintain the ball, shoot, and pass during three different SSG conditions of soccer. Participants included fifteen male soccer players with an average of 6 years of playing experience. Participants were randomly allocated to three five-player teams and played against each team twice for three different game variations and a total of eighteen five-minute games played on a 40 by 20 meter field. The game conditions were: (1) a standard GK + 4 vs 4 + GK format, (2) an overload game with one player in a different colored uniform acting as an offensive player at all times essentially creating a GK + 4 vs 3 + GK game, and (3) another variation of overload that had two players in different uniforms than their peers, acting as full-time offense, creating a GK + 4 vs 2 + GK game scenario. Data were recorded on video and analyzed post hoc using the TACTO software package to generate 2D positional coordinates. Results revealed differences between the standard SSG format and the two players on all-time offense overload condition. The researchers noted that simply subtracting one defensive player had only minor changes on attacking teams' behaviors. However, by subtracting two defensive players, attacking teams were provided with more affordances, which likely generated the differences in maintaining the ball, shooting, and passing. These results are particularly important because they suggest that manipulation of informational sources (i.e., adding or subtracting players) during training, to mimic a game scenario, allows for greater transferability from practice to game play (Pinder, Davids, Renshaw, & Araújo, 2011). In essence, this promotes players' attunement to actions, which enhances action coupling from practice to game play (Travassos et al., 2012).

Item Scaling

Item scaling is a form of constraint that involves task simplification to reduce field size, equipment, or both, as a way of providing young learners a way of playing that closely represents an adult form. A recent systematic review on scaling equipment and playing area highlighted that students preferred using scaled equipment, had higher rates of engagement, and acquired skills faster (Buszard, Reid, Masters, & Farrow, 2016). Twenty-five studies were covered in the systematic review, involving 989 children under the age of 18. One of the studies included in Buszard et al. (2016) systematic review was Timmerman et al. (2015), which examined the effects of scaling tennis nets for sixteen advanced male tennis players from Australia with an average age of ten. Results indicated that players were able to hit flatter shots, which replicated the desired flight path seen in adult tennis games. Furthermore, the authors speculated that players adopted a more aggressive style of play, indicating players were attuned to informational movement opportunities afforded to them by adjusting net height (Araújo, Davids, Bennett, Button, & Chapman, 2004).

Different results for different skill level

Folgado, Lemmink, Frencken, and Sampaio (2012) sought to examine differences of collective behavior amongst U9, U11, and U13 soccer players across two different SSG formats (GK + 3 vs. 3 + GK and GK + 4 vs. 4 + GK). Participants were thirty youth players with ten players in each age group. Data were collected from a total of six eight-minute games on a 30 by 20 meter field. Each participant played in two games; one for each condition for all three age groups. However, the researchers did not indicate how much prior experience the participants had. Collective behavior was measured using players' field position ratio (*lpwratio*) and calculated using MATLAB to formulate players' virtual position files. Results indicated that younger players tended to bunch up closer to the ball in an attempt to solve game demands individually, while their older counterparts demonstrated a team approach through spreading out and passing. Furthermore, the youngest players' *lpwratio* increased during the GK +4 vs. 4 + GK condition, indicating players were more spread out. However, the opposite effect was seen in the older groups with *lpwratio* decreasing indicating older players were more bunched. The authors noted that this may have been due to the older players' ability to move to the ball quicker than their younger counterparts, therefore the additional player on the same field size may have caused the lower *lpwratio*. The researchers noted limitations in the form of small group numbers and that each group completed each condition only once. However, another limitation that may have gone over looked was players' skill levels. It must be noted that older age isn't always an indicator of a more advanced player. With this in mind, the study may have been better conducted by separating students by ability level rather than by age. Despite limitations, these findings indicate that similar constraints may result in different responses based on skill level.

In a series of studies using the same population, Silva and colleagues set out to examine; (1) movement variability between players of various skill levels, (2) differences in movement patterns according to skill level, and (3) constraints that result in employee different numerical relations on coordination tendencies of players (Silva et al., 2014; Silva, Duarte, et al., 2014; Silva, Travassos, et al., 2014). Participants in all three studies comprised of twenty U17 soccer players from two different soccer clubs that could be considered elite and sub-elite. Ten players were classified as elite due to their experience playing at the national level, while the other ten were considered sub-elite due to their experience playing at the regional level. Each group was divided into two teams of five, creating a total of four small teams. Teams consisted of homogeneous skilled players and played against the other team that was classified at the same level. Each team played in three, seven-minute SSG games that had varying field sizes with the largest field size being 55% of the size of a standard soccer field, and each additional field being ten percent small than the previous. This essentially created a large, medium and small field. Data were collected via global positioning tracking devices that tracked players moving coordinates. Findings of Silva, Aguiar, et al., (2014) indicated that pitch size had an effect on both skill groups. When playing on larger fields players typically fell into standard roles and positions that would be seen in a full size game (i.e., defender, midfield, and striker).

In contrast, the smaller sized fields had more variability requiring players to adjust and explore additional areas of the field. These finding are highlighted in Silva, Duarte, et al., (2014), who found that different groups of skill levels to have different shapes based on the data provided from global positioning tracking devices. Lower skilled games showed a higher rate of grouping during all three game types compared to their higher skilled counterparts. Furthermore, high skill players were able to adjust to the changes in field size by implement different strategies based on the affordances provided on the different field sizes. This highlights how implementing the same constraints may result in different behaviors based on students' skill levels. (Silva, Duarte, et al., 2014). The findings of Silva et al., (2014) indicated that there were differences in the numerical relations for coordination tendencies of players based on skill levels. Higher skilled players were able to more easily adapt to the different game styles than the low-skilled players. These findings taken together highlight that the same set of constraints may result in different outcomes for students of different abilities. This is an important finding that stresses the need for further research to examine how different skill levels react to similar constraints. With a better understanding of the relationship between skill level and constraints, teachers and coaches can manipulate constraints based on the students' skill level.

Application of Research to Physical Education

A single player's behavior is dependent on another player's behavior and illustrates how sports can be considered a dynamical system (Pedro Passos et al., 2008). From an ecological dynamics perspective, adjusting constraints may help performers become attuned to the affordances that are available (Fajen et al., 2009; Travassos et al., 2012). When applying constraints to the dynamical system of sports, a teacher could control the variability that they want their students to experience. As illustrated throughout the text above, manipulating constraints in the game of basketball can be used to highlight intended components of the game. For example, a teacher could implement rule changes during practice sessions similar to those used by Almeida and colleagues (2012) where students have to pass a certain number of times before attempting a shot. This form of constraint would help promote ball movement and likely increase opportunities for students to respond. To further increase student learning opportunities, a teacher could use a SSG approach similar to the ones used in various studies (Fenoglio, 2003; Pill & Elliott, 2015; Tallir et al., 2012). The decrease in numbers has been found to increase opportunities to respond and help players transfer skills from practice to game play (Chow, 2013). Another area that could be adopted to help form a nonlinear pedagogy classroom is item scaling. Allowing students to use items that better afford opportunities similar to those seen in adult versions of games has been found to increase success rates and decrease the time it take to learn a skill. Additionally, students have been found to prefer scaled items (Buszard et al., 2016; Timmerman et al., 2015). Finally, another constraint that teachers could implement into the classroom is grouping students based on ability level (Silva, Duarte, et al., 2014). However, this form still needs further research to provide a clear understanding of how students of various skill levels can improve. By understanding how to effectively implement constraints, a teacher can begin to implement SSG that promotes students learning and directs students' perceptions to possible affordances.

Research on Ability Grouping

Categorizing students by their ability (ability grouping) in education has been researched extensively, leading to controversy and conflicting opinions. In fact, there has been such a large volume of research conducted on ability grouping (AG) in education that Steenbergen-Hu, Makel, and Olszewski-Kubilius (2016) recently conducted a second-order meta-analysis. A second-order meta-analysis includes a compilation of meta-analyses to be analyzed in one large comprehensive meta-analysis. However, despite this large body of research, there is still much debate over the benefits and pitfalls of AG.

Ability grouping in education has been a controversial topic in research. Many research studies highlight the benefits of AG (Brock & Hastie, 2016; Hastie, Ward, & Brock, 2016; Lentillon-Kaestner & Patelli, 2016; Steenbergen-Hu et al., 2016), while others list potential negatives and shortcomings (Alba, Sloan, & Sperling, 2011; Belfi, Goos, De Fraine, & Van Damme, 2012; Reid, Clunies-Ross, Goacher, & Vile, 1981; Slavin, 1987; Terwel, 2005). However, before discussing potential benefits and flaws of AG, it is important to identify the operational definition and conceptualizations behind the phrase, "ability grouping". As highlighted by Ireson and Hallam (2001), there are several different terms that have been used to describe AG including: streaming, tracking, banding, setting, regrouping, mixed ability, within-class ability grouping, and cross-age grouping. However, in the current study the two most widely used terms, tracking and AG, will be discussed. The term 'tracking', in particular, has been used interchangeably with AG. Although both terms (ability grouping and tracking) place students into groups based on prior testing, they are actually quite different (Slavin, 1987). Ability grouping is considered to be more flexible and never lasts longer than an academic year. On the other hand, tracking tends to follow students' progression over multiple years and has been implemented in middle and high school classes across the United Kingdom (Tieso, 2003). Despite these differences, the two terms have been interconnected in educational research.

History of Ability Grouping

The history of AG in the United States can be traced back to the 1920's. Before this point, the majority of students came from Anglo-Saxon families, but due to the end of the industrial revolution, a decade of change occurred (Worthy, 2010). During this time, cities in the Northeastern United States began to experience an increase in population. The new population largely consisted of poor, Eastern and Southern Europeans (Lucas, 1999; Oakes, 1985). However, there was also an influx of uneducated rural families and African Americans from the South relocating to the Northeast in the hopes of securing jobs in the cities (Steenbergen-Hu et al., 2016). With the intent to best meet the needs of such a wide variety of students, cities formed two different types of schools: comprehensive and vocational. Advocates for this program thought that the tracking system would meet the students' needs based on their race and socioeconomic background (Worthy, 2010). Each of these schools had a different focus or "track". The track for students in comprehensive schools was focused on preparing students for a college education, while the vocational group was working toward skilled or labor positions in the workforce. Additionally, the most advanced students in the vocational groups were classified by placement in an honors track. This essentially created three different tracks in the vocational school; basic, regular, and honor (Lucas, 1999). Unsurprisingly, the honors and regular track students were typically comprised of white males with a higher socioeconomic background. On the other hand, the basic track consisted of various minority groups and students of lower socioeconomic backgrounds (Worthy, 2010).

The Civil Rights Movement and Disability Rights Movement that transpired from the 1950's through 1970's began to spark social changes and a desire for equal rights.

These social changes likely influenced the research, which began to investigate differences based on separation. As noted above, the tracking system that began in the 1920's separated students into vocational schools based on race, ethnicity and socioeconomic status. In the 1970's through the mid-1980's, studies highlighting the negative effects of tracking began to emerge (Esposito, 1973; Oakes, 1985). For example, Oakes (1985) claimed the tracking system led to social inequalities for those placed in the basic tracks. These findings contributed to a shift in change from the old form of tracking, which placed students in high, regular, or basic tracks for all courses, to a new form of grouping known as the leveled course system (Lucas, 1999). Under the leveled course system, the high, regular, and basic titles remained, but students were able to move between subjects. For example, a student could potentially be placed in an honors History class, but also be enrolled in a basic English class. Although the intent was good, AG under the leveled course system remained similar to the old tracking system because students typically stayed in the basic, regular, or honors courses for all subjects. Furthermore, the racial, ethnic, and socioeconomic separation remained, essentially resulting in the same grouping as the original tracking systems (Lucas, 1999; Worthy, 2010).

The use of AG began to decline during the mid-1980's as a result of research that advocated for equality. For example, Oakes (1985) insisted that the tracking system hindered learning opportunities for the lowest classified students and was therefore perpetuating educational and social inequalities. Furthermore, research surrounding the effects of AG on students' academic achievements claimed students made little to no gains through AG (Slavin, 1987, 1990, 1993). Throughout the remainder of the 1980's and into the mid-1990's, the number of schools using tracking or leveled course systems had been reduced, and in some cases, eliminated tracking all together in some high poverty areas (Loveless, 2013). Consequently the decrease in schools using the tracking system likely contributed to the decline in the amount of research on the topic during the 1990's.

As the new millennium began, the rate of AG started to increase again. According to the National Center for Educational Statistics, the percentage of students placed into AG for reading skyrocketed from 1998 to 2009, from 28% to 71%. Furthermore, the results of a MetLife survey of the American teacher revealed that many teachers expressed concerns that classes had become too mixed in terms of the wide ranges of student ability levels, making it difficult to teach the students effectively (Markow & Cooper, 2008). Data was collected for 1,000 public school teachers from a representative population of the United States through phone interviews. As highlighted by these findings, use of AG is again on the rise, as well as teachers' perceptions that AG could be beneficial for students. As a result, the research on AG has begun to increase, and with it, different trends have become present.

Trends in Ability Grouping

As noted above, the early decades of AG largely consisted of tracking students, which is; placing students in classes based on their race, ethnicity, and social economic status. Furthermore, the intent was to have students remain in the same group for multiple years. Ability grouping, on the other hand, allows for a greater amount of flexibility. For example, a teacher might pair students together based on ability for only one day in a class. Additionally, a teacher might have students that are struggling on the same type of math equations work together as a group one day in class. Moreover, Steenbergen-Hu et al. (2016) second order meta-analysis highlighted the following three key features of AG:

(I) Involves placing students into different classrooms or small groups based on their initial achievement skill levels, readiness, or abilities.

(II) The main purpose of such placement is to create a more homogeneous learning environment so that teachers can provide instruction better matched to students needs and so that students can benefit from interactions with their comparable academic peers.

(III) Such placements are not permanent school administrative arrangements that lead to restrictions of student's graduation, destination, or career paths (Steenbergen-Hu et al., 2016 p. 850-851).

Although these components provide valuable insight into the meaning and purpose of AG, there are four additional classifications. These classifications are known as: between-class, within-class, cross-grade, and special. Each of these classifications will be further discussed in the following text.

The first form of AG is between-classes. This form consists of grouping students from the same grade level into classes of students considered to be at the same ability level; based off prior evaluation. This form of grouping ultimately creates a high, medium, and low class within the same grade. Between-class grouping has typically been utilized in elementary schools and is often referred to as, XYZ grouping, between-class comprehensive grouping, or multilevel classes (Kulik & Kulik, 1992; Mosteller, Light, & Sachs, 1996; Slavin, 1987).

The second form of AG is known as within-class grouping. This form groups students within the same classroom into smaller homogeneous groups of students. This can also be referred to as small group instruction; so long as students are placed in groups according to their ability level (Lou et al., 1996). An example of within-class grouping in physical education is the use of graded competition. Graded competition consists of students competing in leagues with similar skilled students over a season of Sport Education (Siedentop, Hastie, & Van der Mars, 2011). Another example of within-class grouping is pairing students in an English class together based on their previous spelling results. Each of the groups would receive different spelling tests that theoretically best met their current level. Students that are more advanced would work with students at a similar level on more advanced words, while other groups of similarly leveled students would work on spelling words that best met their learning needs. This type of grouping has typically been used in elementary schools where classes are smaller and aides are in the classrooms to help (Steenbergen-Hu et al., 2016).

The third form of AG is cross-grade grouping. This consists of grouping students together despite their grade levels. This form of grouping is typically seen in high school elective courses. For example, seniors and freshman might be in the same physical education, band, computer science, or home economics courses despite the wide gap in age and grade level. The Joplin Plan (Floyd, 1954) places students into different grade levels for reading and is the most common type of cross-grade grouping in a core subject (Steenbergen-Hu et al., 2016).

Finally, the fourth AG type highlighted in the literature is special grouping. This form of grouping is typically utilized in high school when students can take honors and early college enrollment classes. However, this can also be observed at the elementary level in the form of skipping or accelerating a grade level.

Advantages and Disadvantages of Ability Grouping

Advantages and disadvantages of AG have been mentioned throughout research since the 1920's (Ryan & Grecelius, 1927; Slavin, 1987). Those in favor of AG argue that the concept allows teachers to better meet the needs of a wide range of students by placing students into groups and providing instructions suited to the needs of each group. Rink (2006, p. 79) gives an example of how teachers can use AG to help students of various skill levels learn during a unit of basketball. The idea is that by forming homogeneous ability groups, instructions for each group will be better aligned to students' needs and set at a pace that is appropriate for the students in each group. Thus, it is speculated that AG helps prevent students from losing interest in a subject due to the pace being too fast or too slow (Bygren, 2016). These ideas can be summed up by the "Goldilocks effect". In the classic story of *Goldilocks and the Three Bears,* Goldilocks chooses between three options of several different items until she ultimately finds the one variation that was "just right" for her needs. Applying this story to AG helps to demonstrate the idea that students should be placed into a zone that is "just right" for their individual learning needs.

Perhaps the most evident claim against modern AG is one that was implemented during the 1920's tracking system. That is, students placed in the lowest levels of ability groups tend to be made up of minorities and students from working class homes (Alba et al., 2011). In the old tracking system, students were generally grouped into tracks based strictly off these differences, whereas in modern AG, the students tend to fall into these groups as a result of their proven ability level. Essentially, these findings indicate a ‘rich-get-richer effect’, where the highest and most gifted students see the greatest gains in AG. This notion is supported by Oakes' (1985) findings which suggests grouping students maintains the status quo of white students that come from a higher social economic background.

Those against AG believe students that are classified in the lower levels of ability groups are robbed of the opportunity to learn from their peers who are classified in high ability groups (Terwel, 2005). Furthermore, some researchers argue that being placed in a lower group generates lower expectations, which may, in turn, deprive students of an equal education. The idea of lower expectations was proposed by Hallam, Rogers, and Ireson (2008) who noted that teachers’ expectations of students varied based on students’ AG classifications. That is, teachers had higher expectations for students in higher group classifications and lower expectations for students in the lower classifications. Additionally, it has been noted that when AG has been implemented into the classroom, teachers tend to interact more frequently with higher ability groups. Moreover, interactions with high ability groups tend to be more positive than interactions between teachers and lower ability groups (Hallam et al., 2008).

As alluded to above, teachers’ perceptions and attitudes toward AG may play a substantial roll into the effectiveness of AG. Early research indicated that teachers of different subjects tended to have contrasting views of AG. For example, math and foreign language teachers held positive views toward ability grouping, while English, humanities, and art teachers tended to doubt the effectiveness of AG in their subject (Reid et al., 1981). However, more recent research indicated that teachers’ perceptions and attitudes towards AG is mostly influenced by what is practiced at the school they work at (Ireson & Hallam, 2001). As highlighted by Hallam et al. (2008), teachers tend to view the pros of heterogeneous teaching as social gains for students working together with peers of various abilities. The disadvantages are mainly expressed in the difficulty of providing students with the appropriate level of material to give enough challenge for high ability students, but not too difficult for their low ability peers. Basically, teachers find it difficult to meet the needs of the highest students without neglecting the needs of the lower students and vice versa (Hallam et al., 2008). Teachers' perceptions and attitudes of AG may relate to both the positives and negatives of the topic. That is, teachers that view AG positively may have greater success with this form of teaching than teachers that simply believe AG can't be done or will result in negative outcomes for students. However, further research needs to be conducted on teachers' perceptions of AG and the successful implementation of grouping to back this claim.

Similar to teacher perceptions of AG, it is also important to highlight the students' perceptions, as they are the ones who are ultimately affected. It would be beneficial to specifically investigate the effects that AG may have on students' academic self-concept and knowledge outcomes. As noted by Chen, Chang, and He (2003), self-concept is formed when students compare themselves to their peers. This is applicable in academics, sports, and other settings where social comparisons can be drawn. When students compare themselves to their peers, even the highest skilled students are at risk of generating a negative self-concept. For example, students in exclusively high skilled groups may experience the "big-fish-little-pond-effect" (BFLPE) (Chanal, Marsh, Sarrazin, & Bois, 2005), which is a decline in academic or physical self-concept when exposed to other peers at or near the same ability or skill level. Chanal et al. (2005) speculate that when elite athletes are paired with other elites near their same level but aren't the best in their group; they may experience a negative self-concept. Furthermore, a similar skilled athlete that is above and beyond other members of his or her training group would likely have a positive physical self-concept. When applying the BFLPE to AG, the argument could be made that AG may be detrimental to even the highest ability groups in terms of academic or physical self-concept. However, the opposite effect has been suggested to occur when homogeneous skilled players compete with their similar skilled peers (Chanal & Sarrazin, 2007). This effect has been named the "assimilation effect" which claims that student self-concept increases when they know they belong to the best group. In contrast, students grouped in the lowest ability groups with the knowledge that they belong to the lowest group, may see a decrease in self-concept as a result of the assimilation effect.

In an attempt to bridge the gap between those that are for AG, and those that are against it, Slavin (1987) mentioned the use of alternation of homogeneous and heterogeneous grouping, with the idea that a compromise between the two may help students reap the benefit of both, while also attempting to mitigate the perceived flaws of both. However, due to the decline of research in regards to AG in the late 1980's as noted above, little research has investigated the alternation of homogeneous and heterogeneous groups. As noted in Lentillon-Kaestner and Patelli (2016), only a few studies have mentioned the possibility of using a combination of both homogeneous and heterogonous grouping by alternating between the two (Crahay, 2013; Dupriez & Draelants, 2004, 2016; Ireson & Hallam, 2001).

Perhaps one of the best analysis of AG is the recent second order-meta-analysis conducted by Steenbergen-Hu et al. (2016), which analyzed thirteen previous meta-analyses. Eleven of the previous thirteen meta-analyses included studies of between class grouping, six covered special grouping for advanced students. Five of the meta-analysis included within-class AG and four of the previous thirteen meta-analyses included cross-grade grouping studies. Furthermore, twelve of the thirteen meta-analyses broke down the outcomes of AG for high, medium, and low ability students. To prevent individual studies from being analyzed twice, due to their use in multiple meta-analyses, duplicates were eliminated resulting in a total of 172 research studies analyzed These consisted of studies ranging from the 1920’s to the 1990’s with studies lasting anywhere between a week to 7 years. Participants were kindergarten to college students with a range 3,821 to 25,718 included in the meta-analyses. Finally, math, reading, science and social studies were the most common courses that AG was used in.

Results for the thirteen previous meta-analyses were reported using effect sizes but were converted to Hedges’ *g*s, for a slightly more conservative estimate while the level of significance was set at .10. Results for the between classes grouping were taken from thirty-six studies with a Hedges’ *g* value range of -0.54 to 0.19. The overall effects on students were none significant. Furthermore, between classes grouping had nonsignificant differences for high medium and low ability students. Results of special grouping for gifted students were collected from six previous studies with a Hedges’ *gs* range of 0.32 to 0.47. The effects on gifted students academic achievement was positive, moderate and statically significant (Hedges’ $g = 0.37$, 95% CI [0.3, 0.44], p <

.01). These findings indicate that gifted students benefit from being placed in special groups or programs that are designed to serve their needs. Results of within-class grouping were collected from seventeen previous studies with a Hedges' *gs* range of 0.15 to 0.48. The effects of within-class grouping on students overall academic achievement was positive, moderate and statically significant (Hedges' $g = 0.25$, 95% CI [0.18, 0.32], $p < .01$). Furthermore, within-classes grouping for high ability students was positive, moderate and statistically significant (Hedges' $g = 0.29$, 95% CI [0.11, 0.44], $p < .01$). For medium ability students within-classes grouping was positive, small, and statistically significant (Hedges' $g = 0.19$, 95% CI [0.11, 0.27], $p < .01$). Finally, for low ability students within-classes grouping was positive, moderate and statistically significant (Hedges' $g = 0.30$, 95% CI [0.14, 0.45], $p < .01$). Findings for within-class AG highlight how students across all ability levels may see positive gains in overall academic achievement. Cross grade grouping results were collected from seven previous studies with a Hedges' *g* range of 0.19 to 0.39. The effects of cross grade grouping on students overall academic achievement was positive, small and statistically significant. These findings indicate that grouping students from different grades can help improve overall academic achievement. In summary, results indicated that students benefited, in terms of overall academic achievement, from within-class grouping, cross-grade subject grouping, and special grouping for the gifted. Furthermore, high medium and low AG all saw small to moderate gains from within-class ability grouping. However, students did not benefit from between-class grouping, which assigned students into high, medium, or low classes.

Ability Grouping in Physical Education

While there has been an expansive line of research on AG in education, there have been a limited number of studies that have examined AG within physical education. This is in despite of apparent skill differences of students that make up a typical physical education class. Furthermore, given the context of a physical education classroom, it may prove to be a valuable subject to study the effects of AG on students of various skill levels due to the ease of manipulation in the physical education classroom.

Research on AG in physical education has taken place in five main forms, the first of which incorporates studies that use surveys to examine teachers' perceptions of AG in physical education (Hallam et al., 2008; Wilkinson, Penney, & Allin, 2016). The second form, is similar to the first with the difference being students perceptions of ability grouping (Rikard & Banville, 2006). The next form consists of acknowledging different ability levels and attempting to control these differences. This is usually achieved by combining students based on skill level to only compete against similar skilled players (Tallir, Philippaerts, Valcke, Musch, & Lenoir, 2012). The fourth form involves examining the difference of homogeneous and heterogeneous ability groups through a cross-sectional design, that is; comparing students participating in a homogeneous treatment to peers in a control group who participate in standard heterogeneous groups (Brock & Hastie, 2016; Hastie et al., 2016). Only one paper in physical education currently meets that last form, which consists of alternating forms of AG, where students participated in both homogeneous groups and heterogeneous groups (Lentillon-Kaestner & Patelli, 2016).

Wilkinson et al. (2016) sought to provide information about the grouping practices of physical education classes in Northeast England, where tracking is a common practice. Furthermore, the researchers explored teachers' perceptions of AG through tracking and within-class AG. The researchers sent 194 surveys to local middle and high school physical education teachers and received 155 responses back. Results indicated AG via the tracking system was used in 96 of the schools. The highest usage of tracking was indicated to be during the middle school years. Specifically, 77% of teachers indicated that tracking took place during the students' 7th grade year. Furthermore, this number was shown to increase to 94% for 8th grade classes before declining to 51% and 36% for 10th and 11th grade, respectively. These findings indicate that the majority of teachers in Northeast England are utilizing a form of AG through the tracking method for middle school students. It was indicated that the most frequently reported reason for using tracking was: "the practice enabled all pupils to learn, make progress and achieve" (Wilkinson et al., 2016, p. 345). Additionally, of the ninety-six schools that used tracking, 32% indicated they also used within-class AG. Physical education teachers indicated grouping students based on ability enhances learning for all students, likely due to the changes made to make content challenging for the various ability levels.

Hallam et al. (2008) examined physical education teachers' perception of AG. The researchers noted that very little research on teachers' perceptions of AG has taken place outside the core subjects. Furthermore, the studies that have mentioned humanities subjects tend to group them together. Therefore, the researchers aimed to explore art, music, drama, and physical education teachers' perceptions of AG in their respective subjects. Survey data was gathered for forty-five school districts located in England, with a total of ninety-seven physical education teachers providing a response. Results indicated physical education teachers had the strongest support of AG compared to teachers of other subjects. Additionally, physical education teachers indicated they believed the most talented students were held back in mixed classes, and through AG, these students were able to continue to learn and improve. In terms of the negative implications of AG, physical education teachers perceived AG had little impact on personal and social outcomes. Finally, physical education teachers agreed that AG could better meet the students' learning needs across the various ability groups. These studies together (Hallam et al., 2008; Wilkinson et al., 2016) indicate that physical education teachers perceive AG to be positive, thus justifying implementing it in the physical education classroom.

Currently, the second form of research on students' perceptions of AG in physical education is lacking. However, insight can be drawn from a study that examined high school students' attitudes toward physical education (Rikard & Banville, 2006). A total of 515 students in the Northeastern United States completed a questionnaire regarding their attitudes toward physical education. Additionally, 159 students took part in focus group interviews. Pertaining to AG, several students from the focus groups suggested splitting students based on skill level, as a means of making physical education more meaningful. Students were not prompted to bring the topic of grouping up, but generated this conversation on their own (Rikard & Banville, 2006). One student even highlighted how he perceived a past experience of AG to be positive for both high and low skill students. It is important to note that ability levels were not indicated for any students in the study. At this time, due to the lack of research on students' perceptions of AG in physical education, one can only speculate that students of different skill levels may have opposing views on AG.

The third form of ability grouping in physical education can be observed in Tallir, Philippaerts, Valcke, Musch, and Lenoir (2012). Although the researchers were not specifically studying AG they aimed to control difference based on varying skill levels. The researchers sought to compare the amount of learning opportunities in a 3-on-3 basketball game compared to the standard 5-on-5 games. Participants were made up of forty-two 11 to 12 year old basketball players, with only the thirty best players' data being analyzed. Coaches ranked students on a scale of ten to five with ten indicating the highest skilled players and five indicating the lowest skilled players. Based on these rankings students were then matched to play against players that were classified as the same ability level in order to help control for student ability levels.

As noted above the fourth form of AG in physical education used a between subjects design to examine to benefits of AG compared to a control group. Two examples that fall under this fourth form used the Sport Education model to do examine the effect of AG known as graded competition in the Sport Education literature. One of the aims of the Sport Education model is to give all students an equal opportunity to play, which is often achieved through small sided or modified games (Siedentop, 1994). It was later noted that graded competition may prove beneficial in meeting this aim (Siedentop et al., 2011). By using graded competition, students would be separated into different leagues based on their skill and ability level. The idea of graded competition is that by grouping students into different leagues, they would have equal opportunity to play and improve. However, only two studies on Sport Education have investigated the use of graded competition (Brock & Hastie, 2016; Hastie, et al., 2016). In the first study, Brock and Hastie (2016) examined verbal exchanges of 106 fourth grade students in two separate classes throughout a season of handball. One class played in a graded competition format with two separate leagues; one made up of higher skill students, the other compiled of lower skilled students. The other class played in a standard season of handball made up of students of mixed skill levels on each team. Results indicated that lower skilled students that competed in the graded competition class had more interactions with homogeneous peers than their lower skilled counterparts that competed in the mixed ability class. Another finding from this study indicated that the lower skilled students from the graded competition class interacted more frequently than any of the other groups of students in either condition. These findings indicate that lower skilled students may feel more comfortable when placed on a team and competing against other students at or near their same ability level.

The second study that examined the effects of graded competition on students was conducted by Hastie et al. (2016). However, it is important to note this study was conducted in unison with Brock and Hastie (2016) therefore, the participants and the setting were the same. However, the purpose of this study was to examine students' opportunities for involvement and success rates for high and low skilled students competing in a graded competition class compared to their peers in the control class. Results for engagement rate indicated a significant interaction for skill level x condition ($F_{(1,203)} = 10.83, p = .001, \eta^2 = .052$). These findings indicated that the rate of play is higher for high skill students competing in homogenous ability groups. Additionally, results for students percent of success with skill x condition showed a significant interaction ($F_{(1,203)}$ = 7.60, p = .006, η^2 = .037). Indicating that lower skilled students in homogenous groups had a significantly higher rate of success than their peers that participated in mixed skilled games. These findings purpose benefits for both high and low skill students in terms of engagement and opportunities. These findings, taken with those of Brock and Hastie (2016), indicate students may benefit in terms of social interaction, rate of play, and opportunities to play when graded competition is implemented.

The study by Lentillon-Kaestner and Patelli (2016) is one of the few studies that has examined the effect of alternating homogeneous and heterogeneous grouping, and the only study to do so in the physical education setting. Therefore, Lentilon-Kaestner and Patelli (2016) is the only study that falls in the fifth classification of physical education and AG studies. The researchers examined the effects of grouping (based on sex and ability level), on the pleasure experienced in physical education. Pleasure in physical education was measured using a Likert scale of the validated English version of the Physical Activity Enjoyment Scale (PACES). Participants in this study included 178 secondary eighth and ninth grade students. Data for the eighth grade students were collected during a six-week endurance unit. Data was collected for ninth grade students enrolled in an eleven-week basketball unit. A total of seventy-eight students participated in the alternation of skill group, and the remaining 100 students were placed in a control group that consisted of typical mixed ability groups. Alternation of groups rotated every two weeks. This was attained by having students grouped according to skill level for two weeks, then grouped into mixed groups for another two weeks. The alternation of homogeneous and heterogeneous groups had a positive effect on students' pleasure in physical education. Results of grouping were significantly different (p = .04) for those in the basketball unit, while those in the walking unit had a small but non-significant effect. The researchers noted that the alternations of AG might be a good means of meeting students' social needs and learning expectations (Lentillon-Kaestner & Patelli, 2016).

As discussed, research on ability levels in physical education has mainly taken place in five forms. The first form, consists of surveys that have examined how teachers use AG and their perceptions of it, adds evidence that physical education teachers appear to have positive perceptions of AG. The second, form highlights students' perceptions of AG, currently provides minor support that students are in favor of AG. However, further research is need on student perceptions of AG. The Third form, which pairs students based off their ability level in an attempt to control differences, provides no evidence for the potential benefits of AG in physical education. The fourth form of AG, which used a cross-sectional design to compare homogeneous and heterogeneous grouping, has provided valuable insight into how both high and low skill students may reap the benefits of AG. The final form has used a within-subjects design and has allowed comparison to be made with students that have participated in both heterogeneous and homogeneous groups. Future studies should seek to examine performance outcomes similar to those in Hastie et al. (2016) by a means of comparison similar to Lentillon-Kaestner and Patelli (2016). A within-subjects design that investigated students' opportunities to play and success rates in high, mixed, and low skilled games would give valuable insight into the potential benefits of AG, as well as highlight shortcomings. As noted by Mahedero, Calderón, Arias-estero, Hastie, and

Guarino (2015), high and low skill students typically see the least amount of gain in the physical education classroom. The lack of improvement for these two groups might be the results of opposite reasons. The motor noise may be too low for high skill students, whereas it may be too high for low skill students. For example, a college basketball player practicing with third graders would not be expected to improve due to the lower amount of motor noise. On the opposite end of the spectrum, picture a third grader trying to practice with college players. The noise would be too high for even the most advanced of third graders. By grouping students according to their skill levels, the noise for the low skilled players might be turned down enough to help meet their learning needs. On the other hand, the increase in noise for the high skilled players might provide a challenge, ultimately meeting their learning needs and enhancing the learning process. Further research would benefit by examining the learning outcomes, and perceptions of students during an intervention that has students participate in both heterogeneous and homogeneous groups.

A review of the research has documented that by manipulating task constraints (i.e., ball size, field size, number of players), one can increase or decrease the number of affordances available to students. However, minimal research has examined the use of graded competition as a constraint. Drawing on past research on constraints, the current study focused on answering the following questions:

1. Does placing students into homogeneous groups (i.e., low- and high-skilled) increase rate of play for both low- and high-skilled students?
2. Furthermore, does homogeneous grouping lead to a higher performance score than heterogeneous grouping for both high- and low-skilled players?

3. Do students have different movement patterns during game play when in homogeneous or heterogeneous groups?
4. Do students' physical activity levels differ during game play in homogeneous groups?
5. Does homogeneous ability grouping in physical education outperform traditional heterogeneous grouping in terms of opportunity to respond, performance scores, increasing movement patterns, and increasing MVPA levels?

CHAPTER III

METHODOLOGY

Design

This study used a mixed between/within-subjects design with students used as their own control. Students were placed into one of two groups (higher skilled or lower skilled) and participated in a series of games involving different team composition. These compositions consisted of (a) all players classified as having higher-skill levels, (b) all players classified as having lower-skill levels, collectively named "matched ability games" and (c) an equal number of higher- and lower-skilled players, named "mixed ability games."

Participants

The participants in this study were 48 fifth-grade students (26 boys, 22 girls; average age = 10.9 years) from three physical education classes (average size = 58) in an elementary school in the Southeastern United States. Sixteen students (8 higher-skilled and 8 lower-skilled) from each of the three classes were selected after being identified by the classroom teacher and completing the skills test. The school enrolls nearly 500 students, of whom 16% receive free/reduced-price school meals and 89% have English as their first language. The schools' population consists of 50% White, 25% Black, and 25% Asian students. The current studies sample nearly reflected the schools population with 45% White participants, 35% Black, and 20% Asian. Informed consent from legal guardians was acquired through hand-outs and participant assent were obtained by prior to the beginning of data collection. Furthermore, the research protocol was approved by the University's Institutional Review Board for Human Subjects Research.

In order to classify students as higher- or lower-skilled, all students in the three fifth-grade physical education classes completed two field tests similar to those used by Rovegno, Nevett, Brock, and Babiarz, (2001). In the first test, two students passed and caught a ball as they ran alongside each other over a distance of 10 meters. In the second test, one student who was being defended moved to receive a pass from a stationary thrower. Students rotated through the passing, receiving, and defending roles. A six-item dichotomous (yes/no) rubric identical to the one used by Hastie, Ward and Brock (2016) was used to score each students' ability (see Table 3.1). The data collected from the field tests were used to classify students into two skill level groups (higher and lower) by means of a non-hierarchical cluster analysis using the K-means method, with the number of clusters being fixed at two. Once clusters were identified, 16 students from each class (eight from each cluster) were randomly selected and invited to participate in the study.

Table 3.1

Scoring Rubric, for Student Classification of Higher-skilled and Lower-skilled.

Field Test Questions	Answers	
Does the student throw a leading pass?	Yes	No
Does the pass have minimal arch?	Yes	No
Does the student face forward while passing and catching?	Yes	No
Does the student move to open space?	Yes	No

Does the student use an overhand motion when passing?	Yes	No
Does the student catch and throw in good rhythm?	Yes	No

Game Play Format

The game played in this study was based on Harvey's (2007) design of a generic invasion game, and was given the name "Over the Line Ball". The game was chosen as a means of providing a game that students had never played while maintaining concepts that all the students were familiar with (i.e., passing, catching, moving to open space and the concepts of an invasion game).

The playing field was located on an outside area designated to physical education classes, with dimensions of 21 meters long and 15 meters wide with 3 meter long by 15 meter wide end zone scoring areas (see Figure 3.1). The corners of the field were market using three feet high cones while the inside corners were of the scoring zones were marked with 2 feet high cones. White field paint was used to mark every three meters to generate 9 square meters squares for a total of thirty, 9 square meter squares. The mini handball used during game play was 4 inches in diameter.

Figure 3.1. Outdoors Playing Area Used for Over the Line Ball

As is the case in any invasion game, students worked with their teammates to defend their end zone while attacking the zone of the opposing team. Similar to Ultimate Frisbee, the ball could only be passed with the hands, and the player in possession of the ball was only allowed to make a pivot step until they passed the ball. Defensive players were not allowed to strip the ball from the player in possession but were allowed to intercept thrown passes. Any passes that were dropped or incomplete led to a change in possession.

Game Play Protocol

Across four days, all students participated in eight games of Over the Line Ball. Four of these were in matched ability games consisting of either all higher-skilled players or all lower-skilled players. While the other four games were mixed ability that consisted of two higher-skilled and two-lower skilled players on each team. This resulted in 12 lower-skill homogeneous games, 12 higher-skill homogeneous games, and 24 heterogeneous games across all three classes for a total of 48 games.

While the rules remained consistent across all games, each game consisted of a new combination of players, so that each student within a class played with and against every other student while in homogeneous groups, and either with or against all students from their opposite skill category (See Figure 3.2 for Game Play Order) To help reduce a carryover effect that could result from one homogeneous group (e.g., higher-skilled), completing more games before the other homogeneous group (i.e.,, low-skill) and therefore getting more practicing time ahead of the introduction of mixed ability game play, game play was staggered for each of the classes. For example, students in class one played their games in the following order: higher ability, mixed ability, and lower ability, while those in class three played mixed ability games first, followed by those of lower-skilled then higher-skilled.

Lower-Skill				
Set 1			**Set 2**	
1	5		1	3
2	6		2	4
3	7		5	7
4	8		6	8
Set 3			**Set 4**	
1	3		1	2
2	4		3	4
7	5		5	6
8	6		7	8

Higher-Skill				
Set 1			**Set 2**	
9	13		9	11
10	14		10	12
11	15		13	15
12	16		14	16
Set 3			**Set 4**	
9	11		9	10
10	12		11	12
15	13		13	14
16	14		15	16

Figure 3.2 Game Play Order

Game Performance

All of the 48 games played over the course of the study were video recorded. Each time a player was involved in either contact with the ball (via a pass, catch, or interception) or was the target of a pass but did not receive it (the ball was overthrown, underthrown, or intercepted), the resultant action was recorded. Table 3.2 provides the definitions of all these actions.

Table 3.2 Definitions of Skill Performance Options for the Game (inter-observer agreement percentages in parentheses)

Category		Definition
Throwing (98%)		
	Success	The student throws the ball and the intended target catches the ball The student throws the ball and the intended target touches the ball but drops it The student throws the ball and it is in a catchable range for the intended target (in the catching window slightly below waist and slightly above head) The student throws a one bounce pass to a teammate

Nonsuccess	The student throws an interception The student throws the ball too high or low for the intended target to catch The student throws bounce pass that doesn't reach the intended target on the first bounce
Catching (96%)	
Success	The student successfully catches the ball The student bobbles the ball lacking control but never drops it.
Nonsuccess	The student's hand touches the ball but drops it. The student is able to get one hand on the ball but doesn't complete the catch The ball is thrown in a catchable location but the student drops the ball The student bobbles the ball eventually dropping it
Targeted (100%)	
	Pass was intended for a student, but that student never received the ball… due to the pass was intercepted or the pass was uncatchable (see definition above) Mark targeted for the student that the pass was intended for
Intercepted (100%)	
	Student on the opposing team intercepts a pass. Student on the opposing team tips a pass, doesn't catch it but picks it up off the ground to gain possession

The following scores were calculated from the raw data: (a) the percent success of all passes thrown and balls received, and (b) the ball rate of play (the number of in-game actions per minutes of game play). In addition, an overall indication of each player's game performance was calculated based on the formula developed by Gréhaigne, Godbout, and Bouthier (1997). This formula reads as "(efficiency x 10) + (volume of play/2)". Efficiency is established from the following data: (a) the number of opposition throws which are intercepted as well as catches from one's own team, collectively known as recovered throws (RC); (b) the number of jeopardizing passes

(JP), which is the total of successful passes and scoring shots; (c) the number of lost passes (LP), which is the sum of all throws that are either under or overthrown, or are intercepted. The efficiency index is then calculated as follows: Efficiency Index = (RC + JP)/(10 + LP). A participant's volume of play is represented by the number of times the player gains possession of the ball. Validity data for this game performance index are available in the research of Gréhaigne et al. (1997).

The principal investigator and five coders initially performed simultaneous coding of randomly selected games until an agreement rating in excess of 95% was achieved. Each coder then completed a random sample of 25% of the data in order to allow overlap for an additional check of inter-rater reliability. Intra-rater reliability was assessed through intra-observer (14 days after the first observation) and inter-observer testing procedures (performed by the primary investigator) in 60% of the participants. This exceeded the recommended 15% value by (Hopkins 2000; Tallir, Lenoir, Valcke, & Musch, 2007). Values of Cohen's Kappa for intra-observer reliability showed 98% agreement and 96% agreement for inter-observer reliability, exceeding the percentages recommended by van der Mars (1989) as appropriate to suggest strong agreement. Specific item reliabilities are shown in Table 3.2.

Game Play Physical Activity

Physical activity was measured with the Actigraph GT3X triaxial accelerometer (Actigraph, Pensacola, Florida) programmed with a 5s epoch. Accelerometers were worn on the right hip and attached with an elastic belt. The minutes of sedentary behavior, light, moderate, vigorous, and very vigorous physical activity during each lesson was quantified on the basis of calibration studies by the Butte et al. (2014) cut point equation for all students in the study.

Movement Patterns and Team Spacing

Similar to rate of play, percent success, and performance score, data were collected using a camera that was used to record each game. The camera was placed 20 feet high on a hill east of the playing field to fully capture the field. Students wore either white or black pinnies in order to match their team members. Furthermore, players wore a unique color of duct tape on their jersey in order to help with data analysis. For example the duct tape colors for white pinnies were red, black, blue and green. Additionally, the colors used for the black pinnies were red, white, blue and yellow. Several students had to switch pinnies between games in accordance with the player rotation. (See Figure 3.3 for game play map). Data were collected in this fashion to establish players' individual coordination tendencies of dominant regions that each player occupied. Players regions were converted to a 2D mean location for each student across the four games of mixed skill play as well as the four games of matched skill play

Class 1 Day 1 Wednesday 9/6/17 High Skill

Game 1		**Game 2**	
Black pinnies	White pinnies	Black pinnies	White pinnies
9W	13R	9W	11R
10R	14BK	10R	12BK
11B	15B	13B	15B
12Y	16G	14Y	16G
Game 3		**Game 4**	
Black pinnies	White pinnies	Black pinnies	White pinnies
9W	11R	9W	10R
10R	12BK	11R	12BK
15B	13G	13Y	14B
16Y	14B	15B	16G

Class 2 Day 1 Wednesday 9/6/17 low skill

Game 1		**Game 2**	
Black pinnies	White pinnies	Black pinnies	White pinnies
1W	5R	1W	3R
2R	6BK	2R	4BK
3B	7B	5B	7B
4Y	8G	6Y	8G
Game 3		**Game 4**	
Black pinnies	White pinnies	Black pinnies	White pinnies
1W	3R	1W	2R
2R	4BK	3R	4BK
7B	5G	5Y	6B
8Y	6B	7B	8G

Class 3 Day 1 Wednesday 9/6/17 mixed skill set 1

Game 1		**Game 2**	
Black pinnies	White pinnies	Black pinnies	White pinnies
1W	3R	1W	5R
2R	4BK	2R	6BK
9Y	11B	11Y	13B
10B	12G	12B	14G
Game 3		**Game 4**	
Black pinnies	White pinnies	Black pinnies	White pinnies
1W	7R	1W	3R
2R	8BK	2R	4BK
13Y	15B	15Y	9B
14B	16G	16B	10G

Note: Numbers indicate players while letters indicate duct tape color (i.e., W = white, R = Red, Y = yellow, B = Blue, BK = black, and G = green).

Figure 3.3 Example Game Play Map

Each player's 2D mean location was generated by averaging each individual student's location using the grids on the game play field (as shown in Figure 3.1). Students locations were recorded every five seconds for a total of 60 "X" and 60 "Y" coordinates per student in each game. These locations were then averaged based on mixed or matched play. From this process the following variables were derived: each player's average X coordinate, Y coordinate, area occupied, distance traveled, standard deviation in the X-axis, standard deviation in the y-axis, and the elliptical shape of their range of movement, knows as ellipse.

Data Analysis

Game performance and MVPA

The average of each student's percent success, ball engagement rate, game performance as well as their percent time in moderate to vigorous physical activity (MVPA) was calculated for the two conditions (homogeneous and heterogeneous) in which they participated. I began by determining whether game performance level would differ based on child skill level, ability grouping, and child sex. To test this research question, I used a full factorial mixed analysis of variance (MANOVA), where ability grouping (mixed ability games versus matched ability games) served as a within-subjects variable, and student sex and skill level served as between-subjects variables (a 2 x 2 x 2 within-between-between design). To follow up on any significant interactions and explore the pattern of that interaction, a series of two multivariate analyses of variance (MANOVAs) were used, with the data split by student's skill levels. In each, I tested whether percentage completion, rate of play, and game performance would differ based on mixed versus matched ability groupings. I used this procedure to test the patterns of interaction between ability grouping and ability level to explain differences in game performance and physical activity (Keppel & Wickens, 2004). The first MANOVA tested these differences among higher-skilled children, while the second did so for lower-skilled children. To understand how the set of dependent variables varied, follow-up univariate tests were conducted. The Type I error rate was set at $\alpha = .013$ using the Bonferonni correction for multiple comparisons (Pituch & Stevens, 2016).

Predicting MVPA

Multiple ordinal logistic regression analyses were used to determine the influence of game performance, grouping condition (homogeneous or heterogeneous) and sex on MVPA.

Movement patterns

Similar to game performance variables, the average of each student's X coordinate, Y coordinate, area occupied, distance traveled, standard deviation X-axis, standard deviation Y-axis, and ellipse were calculated for the two conditions (homogeneous and heterogeneous) in which they participated. I began by determining whether movement patterns would differ based on student skill level, ability grouping, and student sex. To test this research question, I used a full factorial mixed analysis of variance (MANOVA), where ability grouping (mixed ability games versus matched ability games) served as a within-subjects variable, and student sex and skill level served as between-subjects variables (a 2 x 2 x 2 within-between-between design). To follow up on any significant interactions and explore the pattern of that interaction, a series of two multivariate analyses of variance (MANOVAs) were used, with the data split by student's skill levels. In each, I tested whether the average of each student's X coordinate, Y coordinate, area occupied, distance traveled, standard deviation X-axis, standard deviation Y-axis, and ellipse would differ based on mixed versus matched ability groupings. I used this procedure to test the patterns of interaction between ability grouping and ability level to explain differences in game movement patterns and central location (Keppel & Wickens, 2004). The first MANOVA tested these differences among higher-skilled children, while the second did so for lower-skilled children. To understand how the set of dependent variables varied, follow-up univariate tests were conducted. The Type I error rate was set at $\alpha = .013$ using the Bonferonni correction for multiple comparisons (Pituch & Stevens, 2016).

CHAPTER IV

RESULTS

Game Play

Analysis of the 48 games played resulted in 4,320 in-game actions being coded. These data were then combined to produce descriptive and analytical statistics for each of the dependent variables (percent success, ball engagement, and performance). These data were then used to answer the first three research question that related to the game play variables. Descriptive statistics split by skill level, ability grouping, and sex can be found in Table 4.1.

Table 4.1

Game Play Outcomes by Condition

Game type	Sex	Percent success *M (SD)*	Rate of play *M (SD)*	Game perf. *M (SD)*
All higher skilled	Girls	70.02 (12.63)	2.28 (0.77)	5.18 (2.03)
	Boys	80.99 (11.48)	2.53 (0.66)	6.38 (1.70)
	Total	76.42 (12.94)	2.42 (0.70)	5.88 (1.90)
Higher within mixed	Girls	78.32 (9.82)	2.91 (0.66)	6.63 (1.80)
	Boys	83.02 (9.46)	3.03 (0.77)	8.10 (2.64)
	Total	81.06 (9.69)	3.00 (0.69)	7.49 (2.40)
All lower skilled	Girls	73.52 (11.80)	1.91 (0.84)	4.33 (2.48)
	Boys	75.22 (8.79)	2.30 (0.76)	5.02 (2.36)
	Total	74.37 (20.21)	2.11 (0.82)	4.67 (2.40)
Lower within mixed	Girls	57.52 (15.70)	1.25 (0.53)	2.47 (1.09)
	Boys	65.80 (15.02)	1.55 (0.48)	3.37 (1.34)
	Total	61.66 (15.61)	1.40 (0.52)	2.92 (1.28)

Full Model

I began by determining whether the set of outcome measures (percent success, rate of play, game performance, and physical activity) would differ based on child skill level, ability grouping, and child sex. To test this research question, I used a full factorial mixed analysis of variance (MANOVA), where ability grouping (mixed versus matched ability level) served as a within-subjects variable, and child sex and child skill level served as between-subjects variables (a 2 x 2 x 2 within-between-between design). There was no significant three-way interaction ($\Lambda = .851$, $F_{4,41} = 1.793$, $p = .149$, $R^2 = .149$), nor a significant two-way interaction with ability grouping and child sex ($\Lambda = .947$, $F_{4,41} = .575$, $p = .682$, $R^2 = .053$). However, there was a significant disordinal two-way interaction between ability grouping and child skill level ($\Lambda = .319$, $F_{4,41} = 21.897$, $p < .001$), which accounted for about 68% of the variance in the set of outcome measures ($R^2 = .681$).

Multivariate Analyses to Explore Disordinal Interaction

To follow up on the significant disordinal interaction and explore the pattern of that interaction, a series of two multivariate analyses of variance (MANOVAs) were used, with the data split by student's skill levels. In each, I tested whether percentage completion, rate of play, and game performance would differ based on mixed versus matched ability groupings. I used this procedure to test the patterns of interaction between ability grouping and ability level to explain differences in game performance and physical activity (Keppel & Wickens, 2004).

The first MANOVA tested these differences among higher-skilled children, while the second did so for lower-skilled children. Among higher-skilled children, there was a significant multivariate difference based on mixed versus matched ability games ($\Lambda = .567$, $F_{3,43} = 8.224$, $p < .001$), and ability grouping accounted for about 43% of the variance in the set of dependent variables ($R^2 = .433$). To understand how the set of dependent variables varied, I used follow-up univariate tests. I set the Type I error rate at $\alpha = .013$ using the Bonferonni correction for multiple comparisons (Pituch & Stevens, 2016). Among higher-skilled students, there was a significant difference in rate of play ($F_{1,46} = 9.386$, $p = .004$, $\eta^2 = .169$), and game performance ($F_{1,46} = 6.992$, $p = .011$, $\eta^2 = .132$). However, there was no significant difference in percent success ($F_{1,46} = 2.579$, $p = .115$, $\eta^2 = .053$) between mixed versus matched ability grouping. Higher-skilled children scored higher in percent completion, rate of play, and game performance when playing in mixed ability games.

Among lower-skilled children, there was a significant multivariate difference based on mixed versus matched ability games, as well ($\Lambda = .595$, $F_{3,43} = 7.320$, $p < .001$). Ability grouping accounted for about 41% of the variance in the set of dependent variables among low-skilled children ($R^2 = .405$). Using the same procedure as the first ANOVA, I then tested for univariate differences on each of the dependent variables. For lower-skilled children, there was a significant difference in percent completion ($F_{1,46} = 10.989$, $p = .002$, $\eta^2 = .193$), rate of play ($F_{1,46} = 16.076$, $p < .001$, $\eta^2 = .259$), and game performance ($F_{1,46} = 12.430$, $p = .001$, $\eta^2 = .213$). In all cases, lower-skilled children scored lower on all dependent variables in mixed ability games compared to matched ability games.

This pattern of differences, visually displayed in Figures 4.1-4.3, indicates that in matched ability games, higher- and lower-skilled children perform relatively similarly across all measures. However, in mixed ability games, higher-skilled children perform better, while lower-skilled children perform worse. This pattern is similar for both boys and girls and accounts for a large portion of the variance in these dependent variables.

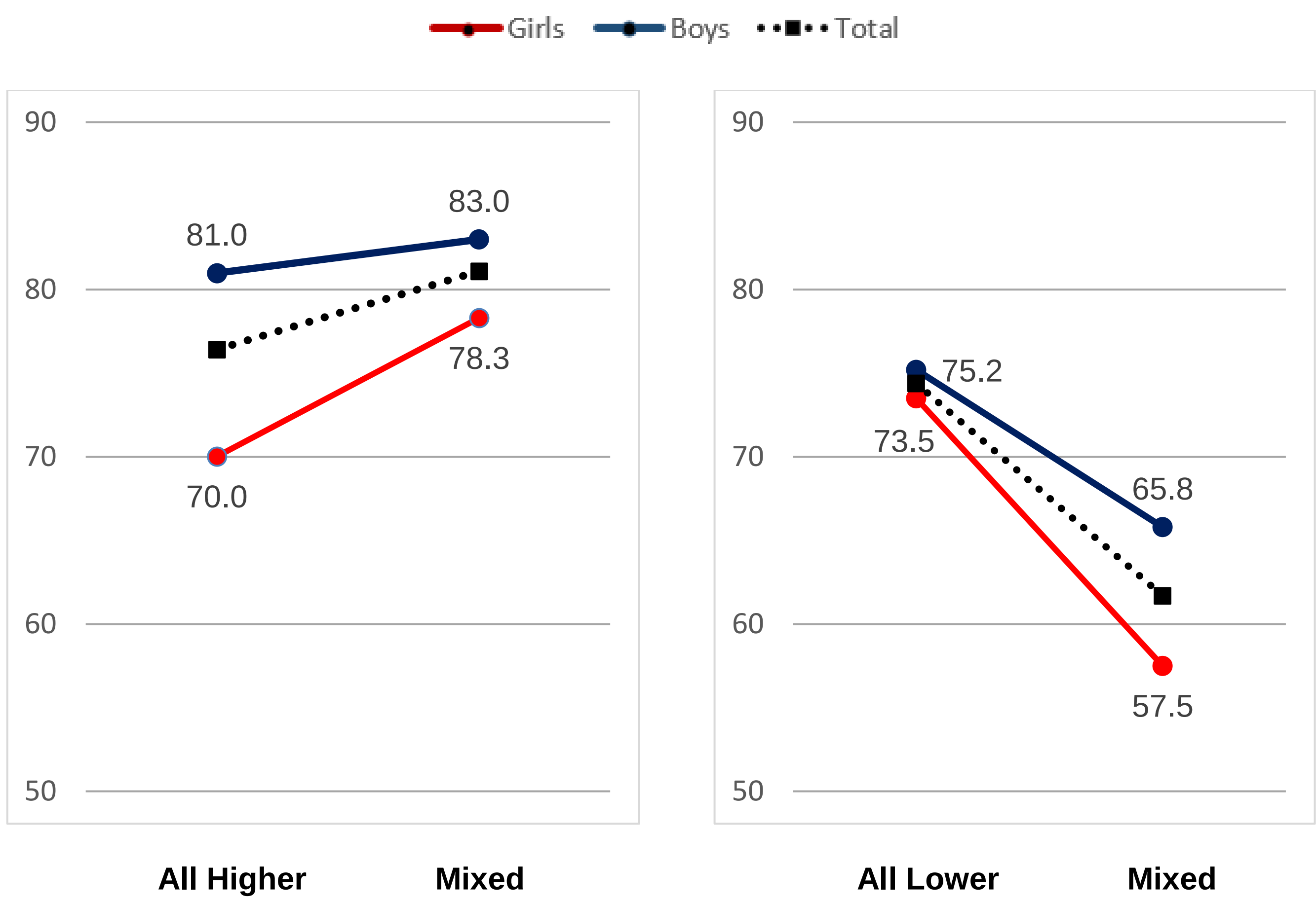

Figure 4.1 Percent Success by Game Type, Skill Level, and Sex

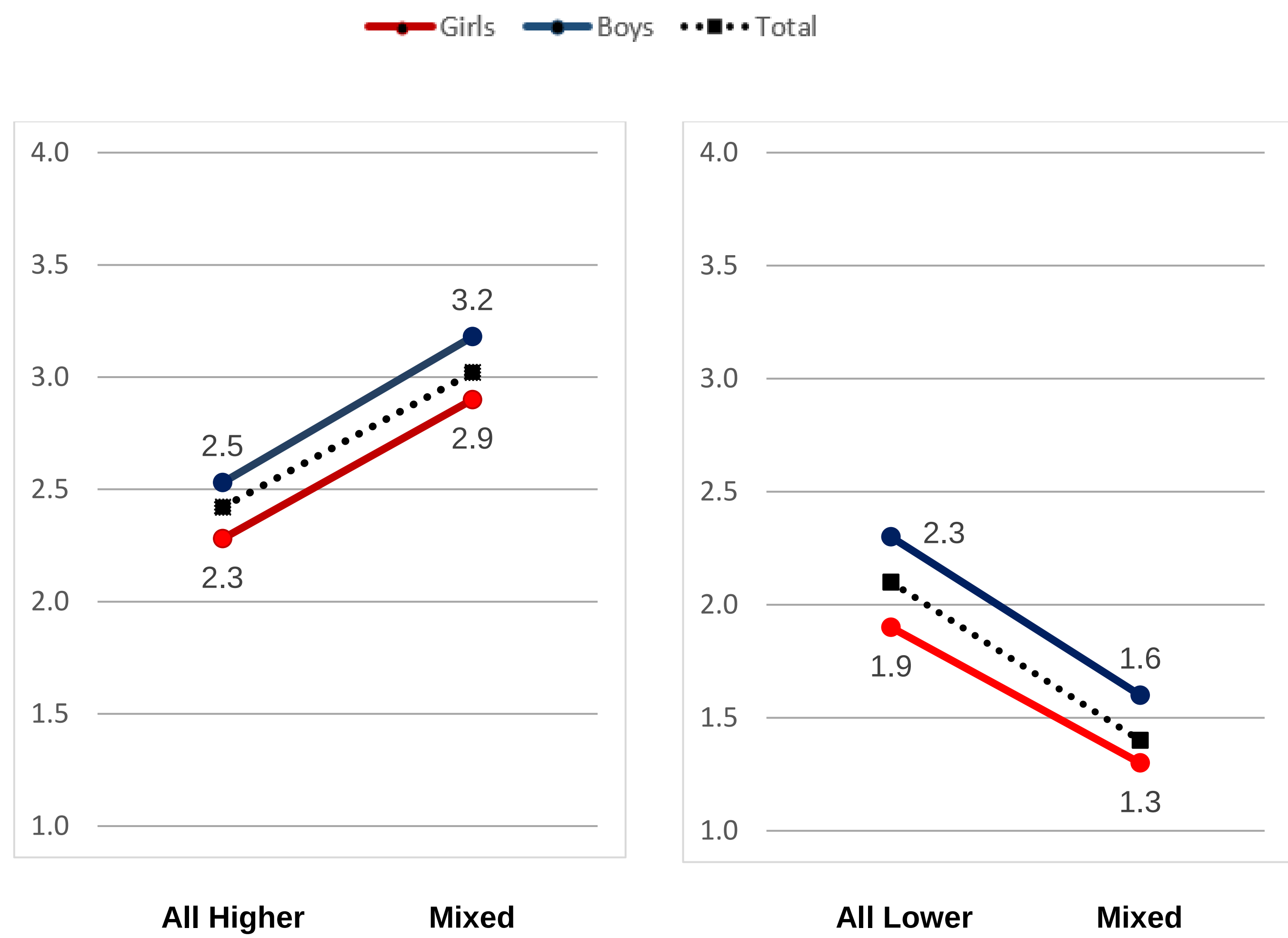

Figure 4.2 Rate of Play by Game Type, Skill Level, and Sex

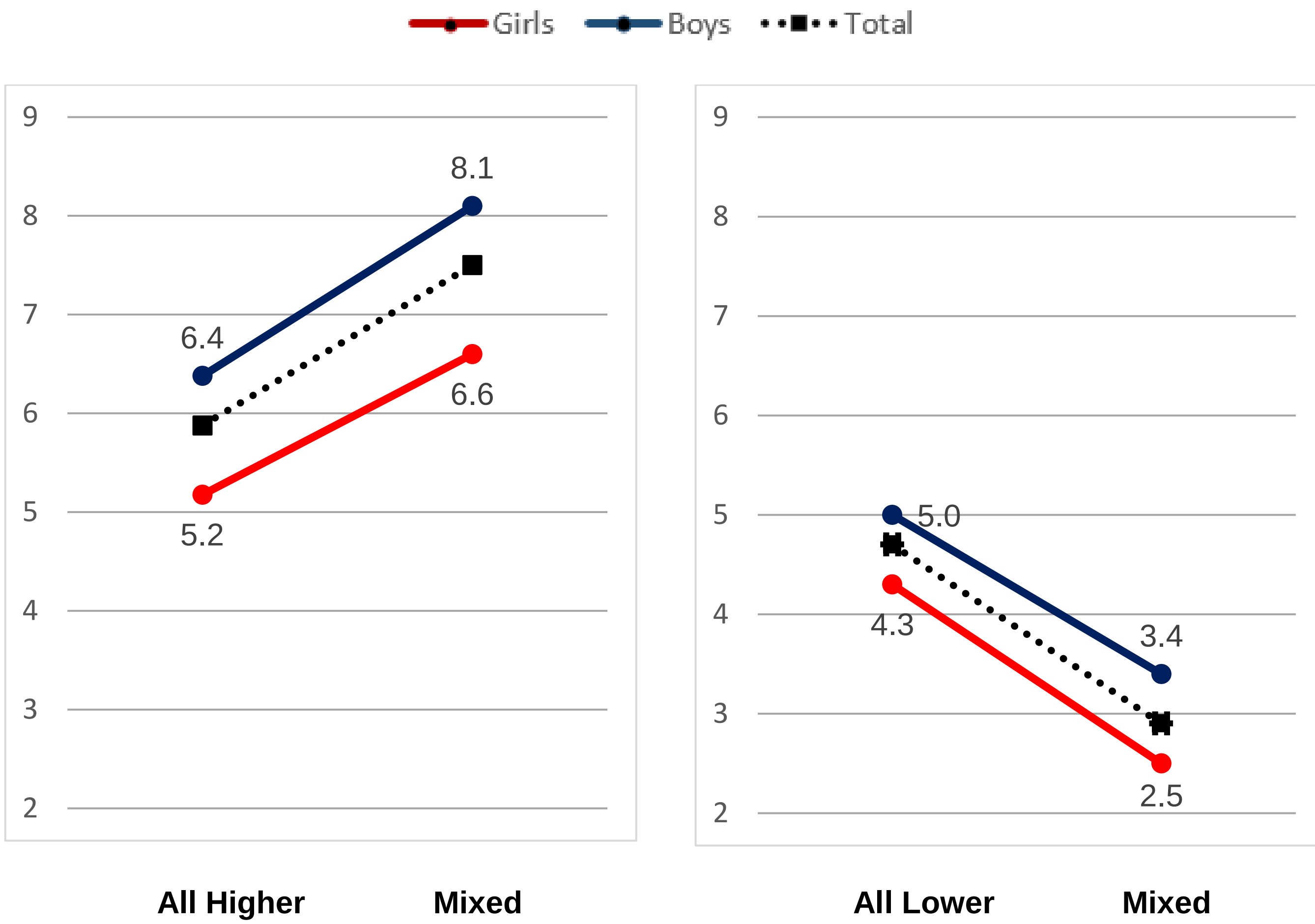

Figure 4.3 Game performance by Game Type, Skill Level, and Sex

Physical Activity

Across the three game types, the students spent an average of 61.6% of game time engaged in MVPA. Of this, 1% was very vigorous, 20.2% was vigorous, 40.3% was moderate, 25.4% was light, and 13.6% was sedentary.

No significant three-way interaction was found ($F_{1,44}$ = 3.415, p = .071, η^2 = .072), and there were also no significant two-way interactions with ability grouping and sex ($F_{1,44}$ = .320, p = .575, η^2 = .007) or between ability grouping and student skill level ($F_{1,44}$ = .320, p = .575, η^2 = .007). Nevertheless, there was a significant main effect, indicating

MVPA varied based on skill level ($F_{1,44}$ = 90.655, p = < .001), and accounted for about 67% of the variance in game performance across all groups (η^2 = .673).

Unlike game play variables, the results indicated an ordinal interaction between skill level and ability grouping. In the case of both high-skilled and low-skilled students, MVPA was significantly lower when playing in mixed ability games MVPA_higher ($F_{1,46}$ = 16.907, p < .001, η^2 = .278); MVPA_lower ($F_{1,46}$ = 18.884, p < .001, η^2 = .300). Figure 4.4 and 4.5 shows the mean time spent in sedentary, light and MVPA by skill level, and ability grouping for higher and lower skilled students.

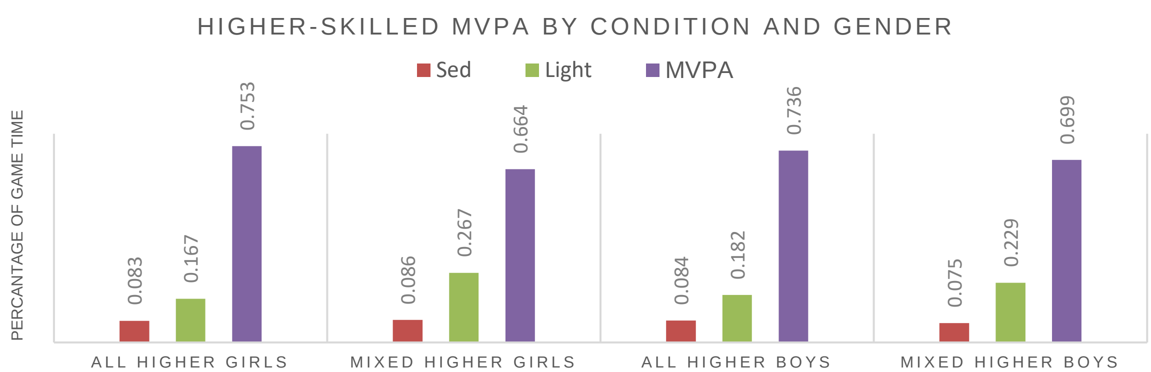

Figure 4.4 Higher Skill Physical Activity Levels by Game Type, Skill Level, and Sex

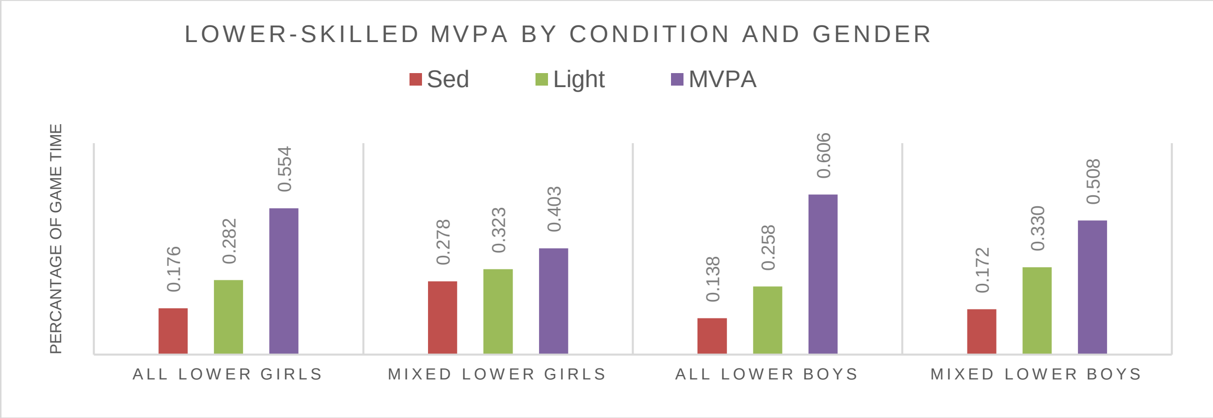

Figure 4.5 Lower-Skilled Physical Activity Levels by Game Type, Skill level and Sex

Predictions of MVPA

In calculating the model, linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. A Durbin-Watson statistic of 1.840 showed there was independence of these residuals. Homoscedasticity was also verified through a visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. Additionally, there were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. Finally, the assumption of normality was met as assessed by Q-Q Plot.

Table 4.2 provides the full details of each regression model including standardized and unstandardized model coefficients. From this table, it can be seen that the addition of skill level and homogeneity (Model 3) provided the best prediction of MVPA over and above game performance scores alone ($F_{1, 92} = 55.35$, $p < .001$; adjusted $R^2 = .64$). That is, the addition of skill to the predictor of MVPA (Model 2) led to a statistically significant increase in R^2 of .23 ($F_{1,92} = 44.28$ $p < .001$), while the addition of homogenous grouping to the prediction of MVPA (Model 3) led to a further statistically significant increase in R^2 of .13 ($F_{1,92} = 33.801$ $p < .001$). Therefore, (Model 3) is accepted as the most appropriate model. However, it is important to note that the addition of sex as a predictor of MVPA (Model 4) did not lead to a statistically significant increase in R^2.

Table 4.2

Hierarchical Multiple Regression Predicting MVPA from Performance Score, Skill Level, Grouping, and Sex

	Model 1		Model 2		Model 3		Model 4	
Variable	B	β	B	β	B	β	B	β
Constant	.462		.553		.557		.564	
Perf Score	.03	.53	.01	.22	.01	.20	.01	.18
Skill level			.81	-.57	.08	-.58	.08	.59
Grouping					.05	0.36	.05	.36
Sex							.01	.09
R^2	.28		.51		.64		.65	
F	36.62*		44.28*		55.35*		42.55*	
ΔR^2	.28		.23		.13		.08	
ΔF	36.62*		44.28*		33.80*		2.13	

Note. * p <.001.

Game Play Movement

Analysis of the 48 games played resulted in 46,080 in-game coordinates being coded. This data was then combined to produce descriptive and analytical statistics for each of the dependent variables (mid X coordinate, mid Y coordinate, distance, area, standard deviation X coordinate, standard deviation Y coordinate, and ellipse). Descriptive statistics split by skill level, ability grouping, and sex can be found in Table 4.3 and 4.4.

Table 4.3

Game Play Movement Means, Distance and Area by Condition

Game type	Sex	Mean X *M (SD)*	Mean Y *M (SD)*	Area (m^2) *M (SD)*	Distance (m) *M (SD)*
All higher skilled	Girls	3.06 (0.11)	3.99 (0.44)	20.22 (2.46)	276.77 (20.93)
	Boys	2.99 (0.21)	3.93 (0.32)	22.16 (6.83)	284.08 (38.28)
	Total	2.98 (0.25)	3.96 (0.37)	21.35 (5.45)	281.03 (31.83)
Higher within mixed	Girls	2.97 (0.21)	4.02 (0.35)	16.37 (2.80)	244.57 (19.40)
	Boys	3.00 (0.22)	3.78 (0.34)	19.71 (4.12)	268.81 (2.64)
	Total	2.99 (0.21)	3.88 (0.36)	18.32 (3.39)	258.71 (25.70)
All lower skilled	Girls	3.00 (0.23)	4.30 (0.62)	9.63 (2.47)	201.57 (24.05)
	Boys	3.09 (0.21)	4.10 (0.33)	13.70 (3.57)	229.12 (33.64)
	Total	3.05 (0.22)	4.20 (0.49)	11.66 (3.65)	215.35 (31.83)
Lower within mixed	Girls	2.89 (0.29)	4.16 (0.41)	12.25 (2.65)	220.05 (23.18)
	Boys	3.13 (0.32)	4.11 (0.37)	15.19 (3.35)	237.94 (26.86)
	Total	3.01 (0.32)	4.13 (0.38)	13.72 (3.32)	229.00 (26.18)

Table 4.4

Game Play Movement Standard Deviations, and Ellipse by Condition

Game type	Sex	SD X (m) *M (SD)*	SD Y (m) *M (SD)*	Ellipse *M (SD)*
All higher skilled	Girls	1.87 (0.19)	3.39 (0.45)	0.79 (0.26)
	Boys	1.98 (0.37)	3.49 (0.56)	1.09 (0.57)
	Total	1.94 (0.31)	3.45 (0.48)	0.96 (0.48)
Higher within mixed	Girls	1.81 (0.19)	2.85 (0.29)	0.96 (0.30)
	Boys	1.96 (0.26)	3.20 (0.36)	0.96 (0.33)
	Total	1.90 (0.24)	3.05 (0.37)	0.96 (0.31)
All lower skilled	Girls	1.30 (0.27)	2.39 (0.27)	0.96 (0.39)
	Boys	1.59 (0.24)	2.70 (0.38)	1.10 (0.47)
	Total	1.44 (0.29)	2.55 (0.36)	1.03 (0.43)
Lower within mixed	Girls	1.45 (0.22)	2.64 (0.34)	0.87 (0.51)
	Boys	1.71 (0.34)	2.83 (0.35)	1.02 (0.52)
	Total	1.58 (0.31)	2.74 (0.35)	0.95 (0.51)

Full Model

I began by determining whether the set of outcome measures (mid X coordinate, mid Y coordinate, distance, area, standard deviation X coordinate, standard deviation Y coordinate, and ellipse) would differ based on child skill level, ability grouping, and child sex. To test this research question, I used a full factorial mixed analysis of variance (MANOVA), where ability grouping (mixed versus matched ability level) served as a within-subjects variable, and child sex and child skill level served as between-subjects variables (a 2 x 2 x 2 within-between-between design). There was no significant three-way interaction (Λ = .883, $F_{4,41}$ = .720, p = .656, R^2 = .117), nor a significant two-way interaction with ability grouping and child sex (Λ = .871, $F_{4,41}$ = .806, p = .588, R^2 = .129). However, there was a significant disordinal two-way interaction between ability grouping and child skill level (Λ = .647, $F_{4,41}$ = 2.962, p = .014), which accounted for about 35% of the variance in the set of outcome measures (R^2 = .353). Follow up tests were used to examine the significant interaction revealed a significant difference for distance, ($F_{1,46}$ = 19.201, p < .001, η^2 = .304), standard deviation X coordinate, ($F_{1,46}$ = 4.133, p = .048, η^2 = .86), standard deviation Y coordinate ($F_{1,46}$ = 21.588, p < .001, η^2 = .329), and area ($F_{1,46}$ = 16.398, p < .001, η^2 = .272).

The following figures represent these differences in pictorial format, Figure 4.5 which shows how higher skilled students covered a greater total area by covering more of the playing field in both side to side, and end zone to end zone directions. These are also shown in representative samples from one higher-skilled and one lower skilled student (Figures 4.6 and 4.7). In these figures, each circle represents the proportion of total game time spent in any individual quadrant. It can be seen that both students were present in almost the same number of quadrants, the higher skilled student's range was more diverse, particularly in the end zone to end zone plane. Figure 4.7 clearly shows how while the lower-skilled player moved up and down the field, there was little variation in the sideways movement of that student.

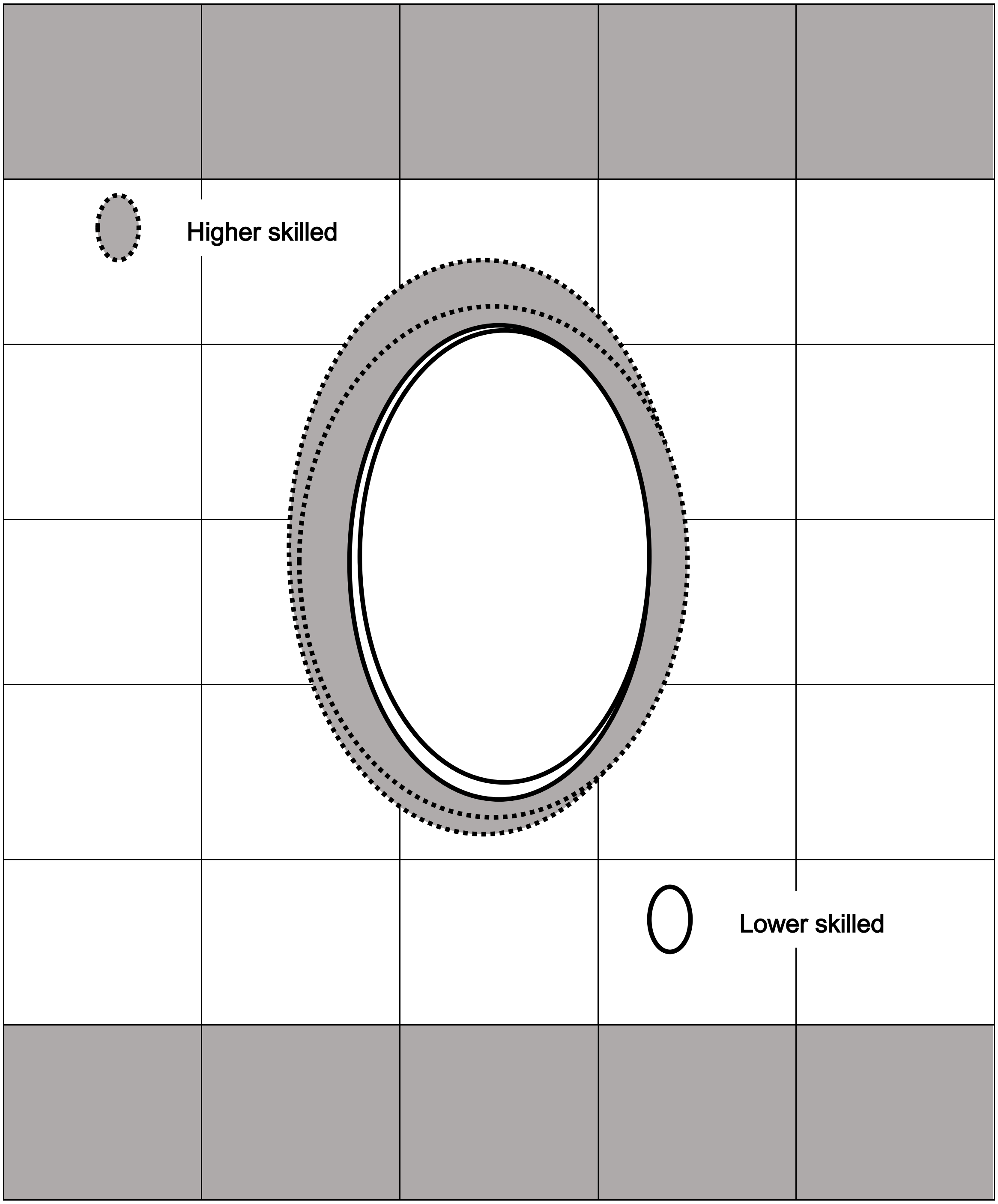

Figure 4.6 Higher-skilled and Lower-skilled Zone Movement Comparison

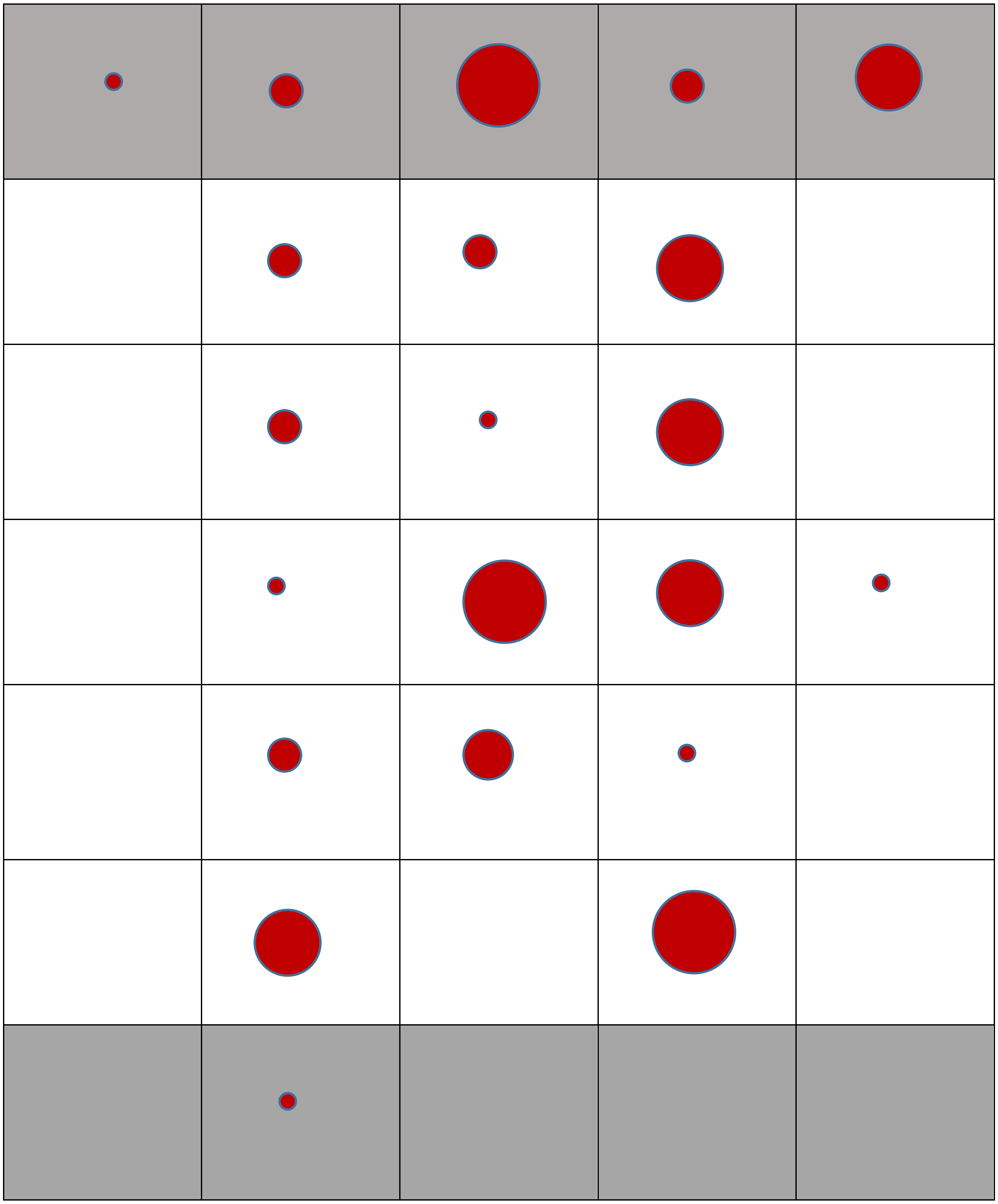

Figure 4.7 Representation of Higher-skilled Mixed Game Time Spent in Quadrants

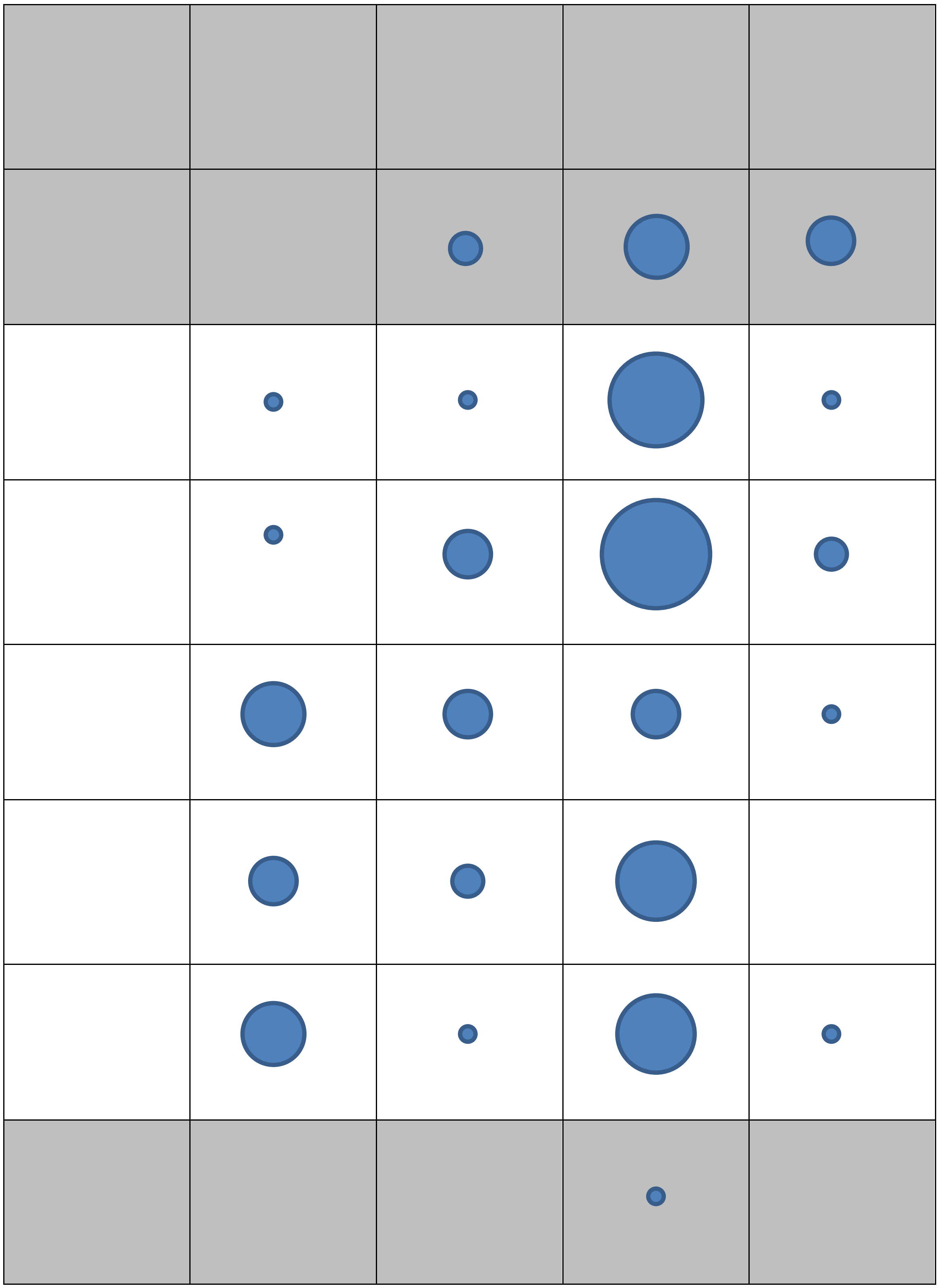

Figure 4.8 Representation of Lower-skilled Mixed Game Time Spent in Quadrants

Multivariate Analyses to Explore Disordinal Interaction

To follow up on the significant disordinal interaction and explore the pattern of that interaction, a series of two multivariate analyses of variance (MANOVAs) were used, with the data split by student's skill levels. In each, I tested whether mid X coordinate, mid Y coordinate, distance, area, standard deviation X coordinate, standard deviation Y coordinate, and ellipse would differ based on mixed versus matched ability groupings. I used this procedure to test the patterns of interaction between ability grouping and ability level to explain differences in game movement (Keppel & Wickens, 2004).

The first MANOVA tested these differences among higher-skilled children, while the second did so for lower-skilled children. Among higher-skilled children, there was a significant multivariate difference based on mixed versus matched ability games ($\Lambda = .438$, $F_{3,43} = 2.937$, $p = .035$), and ability grouping accounted for about 56% of the variance in the set of dependent variables ($R^2 = .562$). To understand how the set of dependent variables varied, I used follow-up univariate tests. I set the Type I error rate at $\alpha = .013$ using the Bonferonni correction for multiple comparisons (Pituch & Stevens, 2016).

Among higher-skilled students, there was a significant difference in distance ($F_{1,46} = 14.207$, $p = .001$, $\eta^2 = .392$), standard deviation Y coordinate ($F_{1,46} = 18.896$, $p < .001$, $\eta^2 = .462$), and area ($F_{1,46} = 7.583$, $p < .012$, $\eta^2 = .256$). However, there were no significant difference in mean X coordinate ($F_{1,46} = .28$, $p = .868$, $\eta^2 = .001$), mean Y coordinate ($F_{1,46} = .476$, $p = .498$, $\eta^2 = .021$), standard deviation X coordinate ($F_{1,46} = .415$, $p = .526$, $\eta^2 = .019$), and ellipse ($F_{1,46} = .128$, $p = .724$, $\eta^2 = .006$) between mixed versus matched ability grouping. Higher-skilled children moved a greater distance, had a larger standard deviation Y coordinate, and occupied a greater area when playing in matched ability games. Figure 4.8 provides a visual account of how higher-skilled children moved a greater distance, had a larger standard deviation Y coordinate, and occupied a greater area when playing in matched ability games.

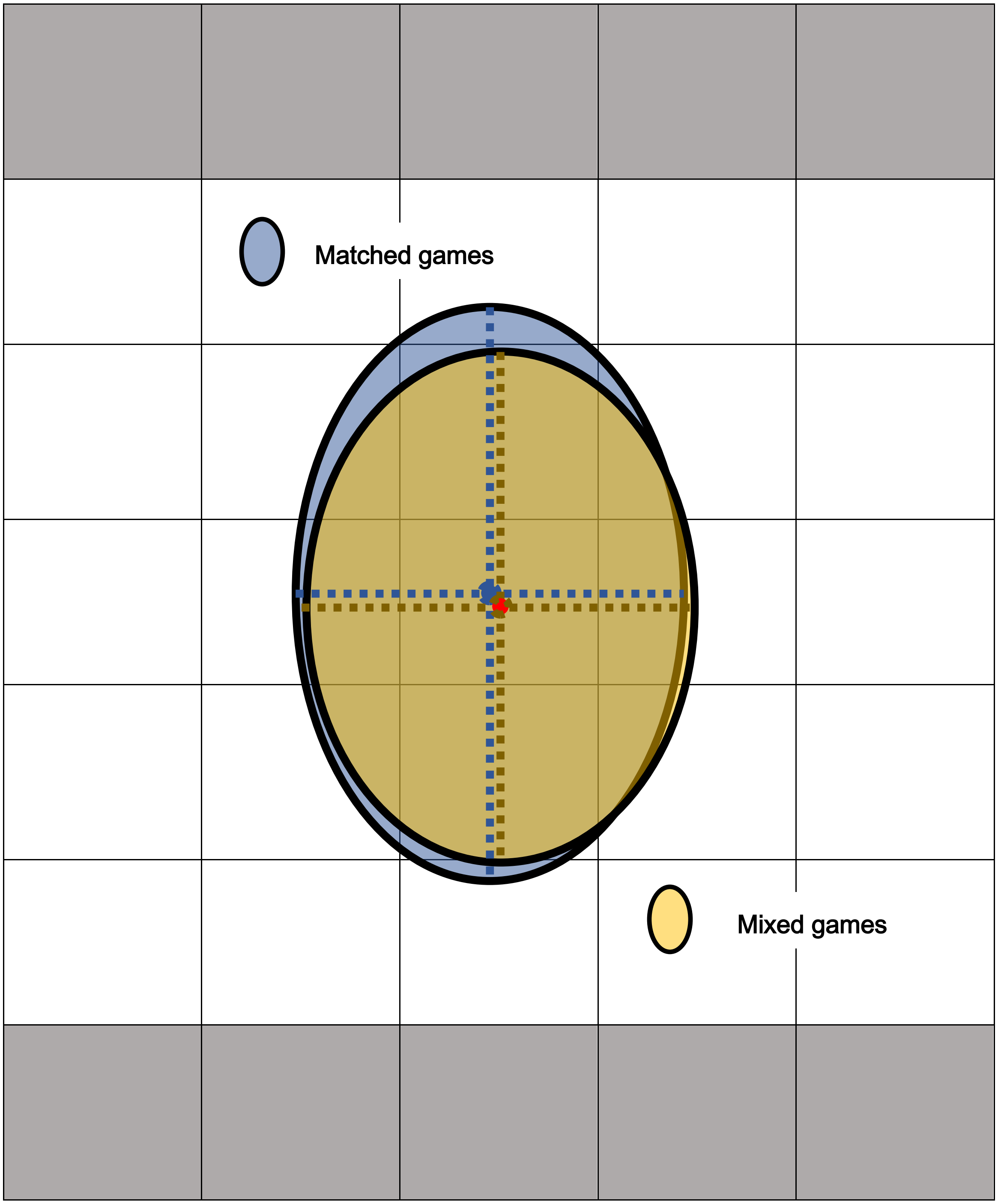

Figure 4.9 Higher-Skilled Students Movement Averages Matched vs. Mixed Games

Among lower-skilled children, there was no significant multivariate difference based on mixed versus matched ability games. However, using the same procedure as the first ANOVA, I tested for univariate differences on each of the dependent variables. For lower-skilled children, there was a significant difference in distance, ($F_{1,46}$ = 5.610, p = .027, η^2 = .203), standard deviation X coordinate, ($F_{1,46}$ = 4.408, p = .030, η^2 = .197), standard deviation Y coordinate ($F_{1,46}$ = 4.609, p = .043, η^2 = .173), and area ($F_{1,46}$ = 11.833, p = .002, η^2 = .350). There was no significant differences in mean X coordinate, ($F_{1,46}$ = .233, p = .634, η^2 = .010), mean Y coordinate, ($F_{1,46}$ = .613, p = .442, η^2 = .027), and ellipse ($F_{1,46}$ = 1.347, p = .258, η^2 = .058) between mixed versus matched ability grouping. Lower-Skilled children moved a greater distance, had a greater standard deviation for their X coordinate, had a greater standard deviation for their Y coordinate, and occupied a greater area while in mixed skill games. Figure 4.9 provides a visual account of how lower-skilled children moved a greater distance, had a larger standard deviation Y coordinate, and occupied a greater area when playing in matched ability games.

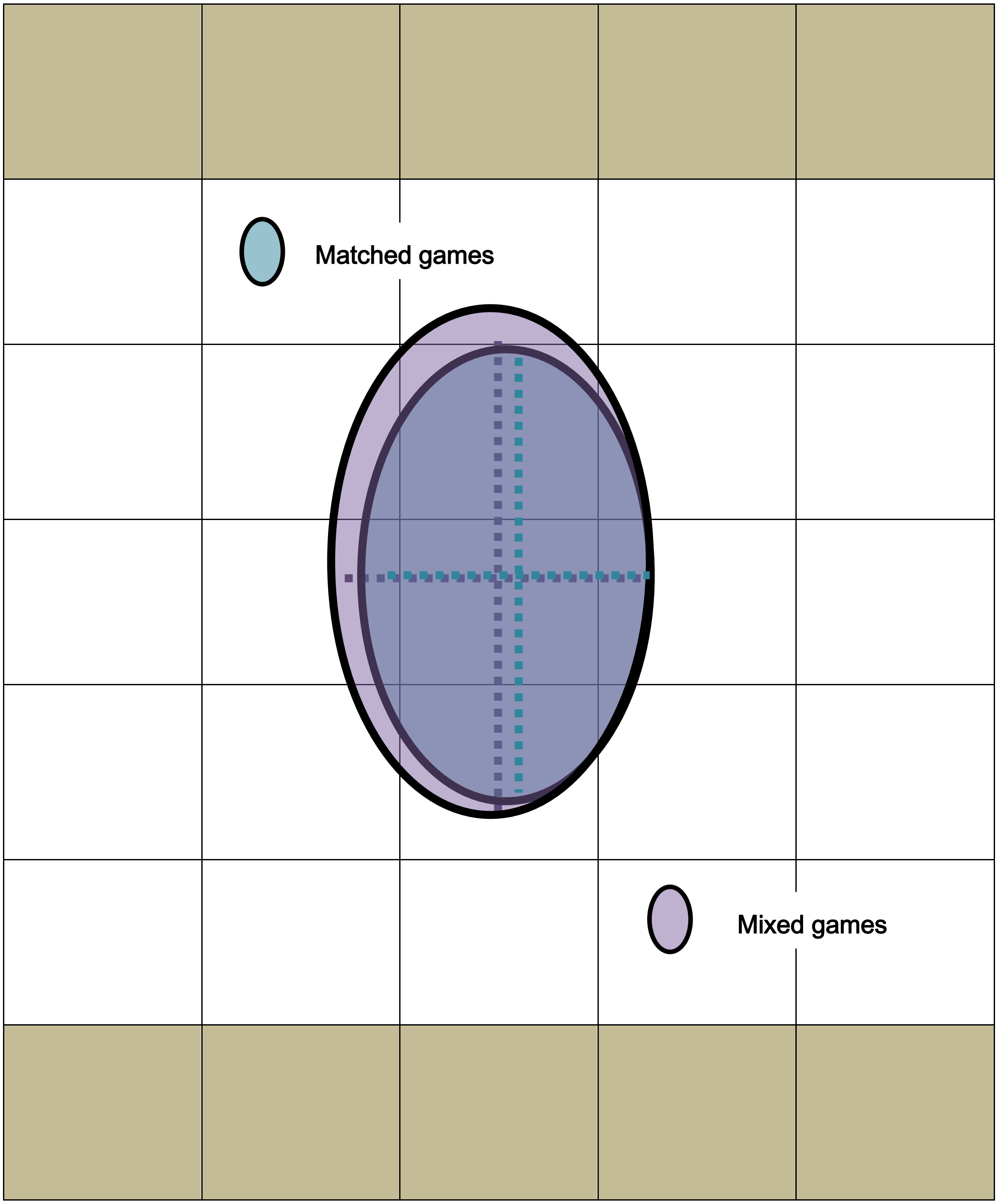
Matched games
Mixed games

Figure 4.10 Lower-Skilled Students Movement Averages Matched vs. Mixed Games

This pattern of differences, visually displayed in Figures 4.5-4.9, indicates that in matched ability games, higher- and lower-skilled children perform relatively similarly across all measures. However, in mixed ability games, higher-skilled children covered a smaller distance and occupied a smaller space, while lower-skilled children covered more distance and occupied more space. This pattern is similar for both boys and girls and accounts for a moderate portion of the variance in these dependent variables.

CHAPTER V

DISCUSSION

This study had six key purposes. These were (1) to determine if placing students into homogeneous groups (i.e., higher-skilled and lower-skilled) would increase the rate of play for each homogeneous group, (2) to determine if students' success rates would increase when placed in homogeneous groups, (3) to determine if homogenous grouping lead to higher performance score for each group, (4) to determine if students have different movement patterns during homogeneous and heterogeneous grouping, (5) to determine if students MVPA levels differ in homogeneous grouping, and (6) to determine if homogeneous ability grouping in physical education outperforms heterogeneous grouping in terms of opportunity to respond, performance scores, increasing movement patterns, and increasing MVPA.

Game Performance

The results of this study provide further evidence for positive benefits of separating students based on skill level. In terms of success rates, rate of play, and game performance lower-skill students appear to suffer during heterogeneous game play. These findings echo the previous findings of Hastie et al. (2016). In terms of success, lower-skilled students saw a decrease in their success rates when playing with their higher-skilled peers. In particular, lower-skilled girls were more at risk than lower-skilled boys showing a larger decrease in success rates during mixed-skill game play. Given that a number of lower-skilled girls state that they do not enjoy game-based physical education, and are often hesitant to participate (Oliver, Hamzeh & McCaughtry 2009; With-Nielsen & Pfister, 2011), constructing lessons where these girls are able to play against those of similar ability levels could be one strategy to promote engagement. It must be stated here that the authors are not implying that girls are all lower-skill and that boys are all higher-skill. However, the data of the current study indicate that lower-skilled girls suffer more than any other group during mixed ability play. With the lowest rates of play, lowest rates of success, lowest performance scores and lowest rates of MVPA it is not surprising that these girls report less than enjoyable experiences.

With respect to throwing and catching, there were times in mixed-skill games where lower-skilled either dropped passes or threw passes that were intercepted in this context but may not have been when playing in homogenous lower-skilled games. The reason behind this might be due to the lower skilled students' inability to estimate affordance of others. Affordances, in this case, are conceptualized as actions that are provided as a result of objects, the environment, and people within the environment (Fajen, Riley, & Turvey, 2009; Hristovski, Davids, Araújo, & Passos, 2011). To translate this into the scenarios witnessed in this study, we are suggesting that when a lower-skilled student threw an interception it was often a result of the lower-skilled student being unaware of the affordance of the other players, either overestimating their teammate's ability to get to the ball or underestimating their opponent's ability to step between the passer and the intended target. Furthermore, when lower-skilled students dropped passes during mixed ability game play, it may well have been due to a higher-skilled player being unaware of the lower-skilled student's lack of ability to catch passes made with strong force (passes that a higher-skilled student could handle with ease). Similar to the observation of Rovegno et al. (2001), it was only higher-skilled players who executed mature strategies such as cutting and faking direction during off the ball movement to create open space. Lower-skilled peers seemed more likely to demonstrate less mature patterns such as jumping up and down or moving back in fourth in what Rovegno et al. (2001) described as a “banana” pathway. While lower-skilled students occasionally got free, there were more likely to remain behind defenders regardless of whether the defender was a lower- or higher-skilled opponent.

In essence, the difference between the higher-skilled and lower-skilled students lay in their ability to adjust to these affordances. From watching the records of game play, it was noted that some of the higher-skilled players adjusted the speed of their passes to better meet the needs of their lower-skilled peers. Some even used hand signals or verbally instructed their lower-skilled peers what to do and where to go. Nevertheless, a tenet most supported from the data concerning rate of play was that a more common adjustment from higher-skilled players was to avoid passing to lower-skilled players after becoming aware of lower-skilled players affordances.

Unlike their lower-skilled peers, higher-skilled players actually increased the success rate of their passes and catches during mixed ability games. Given there were only two higher-skilled players on each team, these pairs would make short quick successful passes particularly while being defended by lower-skilled students. Specifically, higher-skilled players were better at getting open in off the ball situations. Again, this may have been due to higher-skilled players’ ability to better estimate affordances for their teammates and opponents compared to their lower-skilled peers. In addition, and in concordance with the findings of Hastie et al. (2016), higher-skilled students tended to see higher ball engagement rates in mixed ability games play than matched ability games, with both male and female players experiencing similar increases in ball engagement during mixed ability play. As with the success rates, these increases in rate of play can be explained by the increased dependence on the other higher-skilled players. Furthermore, higher-skilled players were more able to make defense plays on lower-skilled students' passes by blocking or intercepting their passes.

The increase rate of play for higher-skilled players came at a cost for the lower-skilled players who experienced decreases in rate of play. Furthermore, the rate of decline was identical for boys and girls. Similar to success rates, as mentioned above, the decline in rate of play can be explained by the structure of the teams where there were a similar number of higher-skilled and lower-skilled players on each team. As noted by Bernstein, Phillips and Silverman (2011) teachers typically consider the structures of teams and attempt to make teams as even as possible by producing homogeneous groups by skill level. While this grouping of students into mixed-skilled teams is done with the intentions to motivate all students, the data from the current study indicates it negatively affects those who are lower-skilled. The observations of Bernstein, Phillips, and Silverman (2011) would support these empirical findings when they identified varying themes of students' participation based on their skill levels during competitive activities. First, while these authors acknowledged skill as a necessary part of competition, they noticed during competitive mixed-skill games that a number of students were in fact not developing skill. Furthermore, they highlighted that lower-skilled students received fewer opportunities to pass and "were often seen as standing around" (Bernstein et al., 2011, p. 75).

The idea that lower-skilled students' physical education experiences in mixed skill settings are less than ideal is not new. For example, Carlson's (1995) qualitative study also found that self-identified lower-skilled students felt isolated in physical education classes, highlighting how giving lower-skilled students a chance to play in matched skill games may prevent feelings of alienation. Even earlier, Griffin's two studies (1984; 1985) provide further examples of the experiences of higher- and lower-skilled girls and boys in physical education. For example, Griffin showed how the "machos," "junior machos," and "athletes" typically dominated play in mixed-skill games and excluded their "lost soul," "cheerleader," "wimp," and "invisible player" peers.

Game Play MVPA

Unlike performance data that indicated higher-skilled students had expanded opportunities in mixed-skill games, both higher- and lower-skilled students accrued lower levels of MVPA during mixed ability game play. This may be explained in part by Newell's (1986) three classifications of constraints: performer, environmental, and task constraints. First, the interplay of the two subcategories of performer (i.e., structural and functional) may have made a significant contribution to both skill groups seeing a decrease in MVPA during mixed-skill games play. Specifically, the structural constraints of lower-skilled students meant the distance and speed with which they threw the ball resulted in shorter slower passes, and thus decreased needs for moving quickly into space to get open and receive passes. In addition, after becoming attuned to lower skilled-players' constraints and affordances, higher-skilled players adjusted by staying closer when lower-skilled teammates were in possession of the ball. By making these adjustments, to retain possession of the ball, higher-skilled students too experienced lower rates of these MVPA producing actions during mixed-skill games. In addition, certain functional constraints of lower-skilled players may have contributed to lower levels of MVPA in mixed-skilled games. The data indicates lower-skilled players in mixed-skill games scarcely receive the ball and when they do, they had lower success rates compared to matched skill games. This likely results in reduced motivation to move to open space which would be classified as a functional constraint.

It is important to note that MVPA in this study was measured exclusively during games and not during a lesson containing game play. Therefore it cannot be stated that either ability group was able to meet the recommendation of 50% of class time spent in MVPA (U.S. Department of Health and Human Services, 2010). What is important to highlight is that if lower-skilled students competing in mixed-skill games are unable to attain this 50% level during gameplay, a situation where students might be expected to be particularly active, it is unlikely they will be able to meet the goal of 50% of class time spent in MVPA. As noted by McKenzie et al. (1995) and McKenzie, Marshall, Sallis, and Conway (2000) MVPA can vary based on location, sex, lesson context, teacher sex, and numerous other factors. However, a common finding from aforementioned studies was MVPA typically is under the recommend 50% of class time regardless of location or lesson context. Given the current lack of research on ability groupings relationship to MVPA and the findings of the current study that indicate MVPA may increase in homogeneous game play for both higher- and lower-skilled students, more research needs to be conducted.

Movement Patterns

The results from movement patterns indicated that lower-skilled students had a statistically significantly greater standard deviation for their Y coordinates, distance traveled, and area occupied during mixed skilled game play. In contrast, higher-skilled students had statistically significantly decreases in standard deviation Y coordinates, distance traveled, and area occupied during mixed skilled game play compared to match skill play. Despite the higher-skilled students' experiencing lower scores in mixed skill play and the lower-skilled students experiencing an increase in their scores during mixed skill play, the higher-skilled students had greater scores for area, distance, standard deviation Y and standard deviation X coordinates during mixed skill play. This might be explained by how game play took place. As noted earlier, higher-skilled students playing in mixed-skilled games would usually exclude their lower-skilled teammates by passing back and forth with their higher-skilled teammate. Similar to what was noted for MVPA, higher-skilled students who had possession of the ball could not move. Therefore they had lower rates of distance traveled, smaller standard deviation of movement for their Y coordinates, and occupied less area during mixed-skill play. The lower-skilled students' higher rates may have been a result of trying to follow their higher-skilled peers around the field.

Similar to Silva et al. (2014) the current study noted higher skilled players had better spacing than lower skilled players. However, unlike the finding of Silva et al. (2014) the higher-skilled students in the current study displayed more oval shapes that ran in a longitudinal direction of the field than lower-skilled peers. This could possibly be due to the age differences between the subjects in the two studies or possibly due to the differences in game types. Regardless the current study used a stronger design that allowed students to play both in multiple mixed and match ability group games. Perhaps only reporting data from one higher and one lower skilled game as was done in Silva et al. (2014) did not provide clear evidence of students movement patterns.

Future Research,

As noted earlier, this study only focused on one grade level of students. Similar to Hastie (2016) 4th grade students were used as the participants. Given that the amount of MVPA decreases over time and the decreases at a more rapid rate for girls' ability grouping should be tested on older students to see if it is a viable option to keep MVPA levels up as students' age. Additionally, the performance variables should examined for older students to see if the positive finding apply to older populations.

Furthermore, future studies should seek to use a qualitative measure to examine students' perception of ability grouping both before and after participating in ability groups. As it relates to the physical education literature on ability grouping only (Rikard & Banville (2006) mentions students' perceptions of ability grouping. However, the study examined students' attitudes towards physical education and merely had a student make the comment about his past experience of ability grouping. At this time, due to the lack of research on students' perceptions of ability grouping in physical education, one can only speculate that students of different skill levels may have opposing views on AG. By learning more about students' perception of ability grouping researchers and educators could then begin to examine proper ways to implement ability grouping into the classroom setting to help prevent potential negatives of ability grouping on students' perceptions.

A future study that could be conducted from the results of the current study could replicate the design but have students complete a survey and/or a brief interview after each game evaluating their perceived competence. By having this data a comparison could then be made of student's perceived competence during heterogeneous game play and homogeneous game play. These finding could help provide motivational evidence for or against ability grouping.

Limitations

In the current study only one school was used for the purpose of data collection. For future studies it would be important to collect data from multiple schools, to account for potential variance in skill abilities. It may well have been that the lower skilled students in this cohort would have been higher performers in other settings. Further, the effect of ability grouping was only tested on one grade level. This limited sample hinders the ability to generalize the findings of the current study to a broader population.

The present study was conducted in an outdoor setting which resulted in two days interference due to inclement weather. Future studies would benefit from data collection in indoor settings, where a number of environmental factors (e.g. the sun in a student's eye, the wind altering a pass, wet grass) could be controlled. Additionally, another limitation that could potentially be resolved from inside would be having a camera centered perfectly above the playing area. The current study used a camera placed on a hill to the East of the playing field and the length of the playing field ran east to west. This made it difficult at times to determine the location of students especially as students moved further west. By using an indoor space with a ceiling high enough a camera could be hoisted up high enough to cover the field. This would provide an ideal visual for player spacing during game play. Using such a method would make smaller cubic square measurements possible which in turn might yield a better representation of student spacing.

It must be stated that the five meter by seven meter grid that was made up of thirty five, nine-square meter squares was not the original plan of measuring students' movement patterns. Originally a visual software package was intended to be used. However, the amount of “noise” created from all the students' movement, the balls movement, and the outside environment was too much for the software package. Therefore the grid system used in the study was a backup. The nine squared meters of the squares might have been too much space to accurately pick up differences in students' movement. Furthermore, as stated in the methods, students' movement was reported every five seconds. This timer interval would have been reduced to thirty frames per-second if the software would have been used. The five second data may have been too long an interval to most accurately document the students' movement patterns.

Conclusion

Similar to Hastie et al. (2016), the results from this study provide evidence that students benefit from being placed in game environments with peers of similar ability levels. Furthermore, the current study used a stronger design than previous research, in which a within-subjects design allowed participants to experience both heterogeneous game play and homogenous game play. In addition, the current study adds to the body of knowledge of ability grouping by showing the impact ability grouping has on students' MVPA. Specifically, the findings indicate that lower-skilled students were able to have a greater amount of time spent participating in MVPA during homogeneous game play compared to heterogeneous game play. Furthermore, higher-skilled students saw the highest level of MVPA of the three different game types during homogeneous play and experienced reduced levels of MVPA during heterogeneous play. Finally, this study was able to use performance scores, skill levels, game type, and sex to predict MVPA. A unique finding in this case was that students' sex did not contribute to the prediction of MVPA. This indicates that a students' skill level is a better predictor of MVPA than their sex.

Despite the limitation, this study contributes to our understanding of within class homogeneous ability grouping on primary students in physical education in the following ways: First, it provides a clear advantage for low skill students' success rates. As previously mentioned, having success is a key to motor competence and developmental trajectories of health. In other words lower skilled students competing in homogeneous groups will have higher success rates and likely have higher rates of perceived competence. Additional research could potentially provide a deeper understanding of how ability grouping can enhance the learning and motivational experiences of all students of all ages. Furthermore, future research on ability grouping could help generate more equitable physical education classes for students of all skill levels.

REFERENCES

Alba, R., Sloan, J., & Sperling, J. (2011). The integration imperative: The children of low-status immigrants in the schools of wealthy societies. *Annual Review of Sociology*, *37*, 395-415.

Almeida, C. H., Ferreira, A. P., & Volossovitch, A. (2012). Manipulating task constraints in small-sided soccer games: Performance analysis and practical implications. *The Open Sports Science Journal*, *5*, 174-180.

Araújo, D., Davids, K., Bennett, S. J., Button, C., & Chapman, G. (2004). 19 Emergence of sport skills under constraints. *Skill acquisition in sport: Research, theory and practice*, 409-433.

Araújo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise, 6,* 653-676

Araújo, D., Davids, K., & Passos, P. (2007). Ecological validity, representative design, and correspondence between experimental task constraints and behavioral setting: Comment on rogers, kadar, and costall (2005). *Ecological Psychology*, *19*(1), 69-78.

Baron, R. M., & Boudreau, L. A. (1987). An ecological perspective on integrating personality and social psychology. *Journal of Personality and Social Psychology*, *53*(6), 1222-1228.

Beek, P., Jacobs, D., Daffertshofer, A., & Huys, R. (2003). Expert performance in sport: Views from the joint perspectives of ecological psychology and dynamical systems theory. In J.L. Starkes, & K.A. Ericsson (Eds.), *Expert performance in sports* (pp. 321- 244). Champaign, IL: Human Kinetics.

Brock, S., & Hastie, P.A. (2016). Students verbal exchanges and dynamics during Sport Education. *European Physical Education Review*, 23(3): 354-365

Brymer, E., & Davids, K. (2013). Ecological dynamics as a theoretical framework for development of sustainable behaviours towards the environment. *Environmental Education Research*, *19*(1), 45-63.

Buszard, T., Reid, M., Masters, R., & Farrow, D. (2016). Scaling the equipment and play area in children's sport to improve motor skill acquisition: A systematic review. *Sports Medicine*, *46(6)* 829-843.

Butte, N. F., Wong, W. W., Lee, J. S., Adolph, A. L., Puyau, M. R., & Zakeri, I. F. (2014). Prediction of energy expenditure and physical activity in preschoolers. *Medicine and Science in Sports and Exercise*, *46(6)*, 1216-1226.

Bygren, M. (2016). Ability groupings effects on grades and the attainment of higher education: A natural experiment. *Sociology of Education*, *89*, 118-136.

Chow, J. Y. (2013). Nonlinear learning underpinning pedagogy: Evidence, challenges, and implications the call for understanding nonlinear learning. *Quest*, *65(4)*, 469-484.

Chow, J. Y., Davids, K. W., Button, C., Renshaw, I., Shuttleworth, R., & Uehara, L. A. (2009). Nonlinear pedagogy: implications for teaching games for understanding (TGfU). TGfU: simply good pedagogy: understanding a complex challenge, 1, 131-143.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., & Renshaw, I. (2007). The role of nonlinear pedagogy in physical education teaching games for understanding. *Review of Educational Research*, *77*(3), 251-278.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araujo, D. (2006). Nonlinear pedagogy: a constraints-led framework for understanding emergence of game play and movement skills. *Nonlinear Dynamics, Psychology, and Life Sciences*, *10*(1), 71-103.

Chow, J. Y., Davids, K., Hristovski, R., Araújo, D., & Passos, P. (2011). Nonlinear pedagogy: Learning design for self-organizing neurobiological systems. *New Ideas in Psychology*, *29*(2), 189-200.

Clark, J. E. (1995). On becoming skillful: Patterns and constraints. *Research Quarterly for Exercise and Sport*, *66*(3), 173-183.

Crahay, M. (2000). L'école peut-elle être juste et efficace?: De l'égalité des chances à l'égalité des acquis. (Can school be fair and effective?: From equality of opportunity to equality of achievement). Brussels, Belguim: De Boeck.

Davids, K., Araújo, D., Hristovski, R., Passos, P., & Chow, J. Y. (2012). Ecological dynamics and motor learning design in sport. In N.J. Hodges & A.M. Williams (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 112-130). New York, NY: Routledge.

Davids, K., Araujo, D., & Shuttleworth, R. (2005). Applications of dynamical systems theory to football. *Science and Football V*, (i), 537-550.

Davids, K., Bennett, S., & Newell, K. M. (2006). *Movement system variability*: Champaign: IL: Human kinetics.

Davids, K., Glazier, P., Araújo, D., & Bartlett, R. (2003). Movement systems as dynamical systems: The functional role of variability and its implications for sports medicine. *Sports Medicine*, *33*(4), 245-260.

Davids, K., Kingsbury, D., Bennett, S., & Handford, C. (2001). Information-movement coupling: Implications for the organization of research and practice during acquisition of self-paced extrinsic timing skills. *Journal of Sports Sciences*, *19*(2), 117-127.

Dupriez, V., & Draelants, H. (2004). Classes homogènes versus classes hétérogènes: Les apports de la recherche à l'analyse de la problématique. (Homogeneous classes versus heterogeneous classes: The contributions of research to the analysis of the problem.) *Revue Française de Pédagogie, 148*, 145-166.

Fajen, B. R., Riley, M. A., & Turvey, M. T. (2009). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, *40*(1), 79-107.

Fenoglio, R. (2003). The Manchester United 4 v 4 pilot scheme for U-9's part II: The analysis. *Insight FA Coaches Assoc. J*, 21-24.

Folgado, H., Lemmink, K. A. P. M., Frencken, W. G. P., & Sampaio, J. E. (2014). Length, width and centroid distance as measures of teams tactical performance in youth football. *European Journal of Sport Science*, *14*(1), 487-492.

Ganter, N., Witte, K., & Edelmann-Nusser, J. (2011). The development of cycling performance during the training program: An analysis using dynamical systems theory. *International Journal of Computer Science in Sport*, *10*(1), 5-25.

Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston, MA: Houghton Mifflin.

Gréhaigne, J. F., Godbout, P., & Bouthier, D. (1997). Performance assessment in team sports. *Journal of Teaching in Physical Education, 16*(4), 500-516.

Hallam, S., Rogers, L., & Ireson, J. (2008). Ability grouping in the secondary school:

attitude of teachers of practically based subjects. *International Journal of Research and Method in Education, 31,* 181-192.

Harvey, S., (2007) Using a generic invasion game for assessment. *Journal of Physical Education, Recreation & Dance*, *78*(4), 19-50.

Hastie, P. A., Ward, J. K., & Brock, S. J. (2016). Effect of graded competition on student opportunities for participation and success rates during a season of Sport Education. *Physical Education & Sport Pedagogy*, *22*, 316-327.

Haywood, K., & Getchell, N. (2014). *Life span motor development* (6th ed). Champaign, IL: Human Kinetics.

Hopkins, W. G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine 30*(1), 1-15.

Hristovski, R., Davids, K., Araújo, D., & Passos, P. (2011). Constraints-induced emergence of functional novelty in complex neurobiological systems: a basis for creativity in sport. *Nonlinear Dynamics, Psychology, and Life Sciences*, *15*(2), 175-206.

Ireson, J., & Hallam, S. (2001). *Ability grouping in education*. London: Sage.

Kelso, J. A. (1995). *Dynamic patterns: The self-organization of brain and behavior*. Cambridge: MA: MIT press.

Konczak, J. (1990). Toward an ecological theory of motor development: the relevance of the Gibsonian approach to vision for motor development research. *Advances in Motor Development Research*, *3*, 3-17.

Lentillon-Kaestner, V., & Patelli, G. (2016). Effects of grouping forms, student gender and ability level on the pleasure experienced in physical education. *Journal of*

Teaching in Physical Education, *35*, 251-262.

Lonsdale, C., & Tam, J. T. M. (2008). On the temporal and behavioural consistency of pre-performance routines: an intra-individual analysis of elite basketball players' free throw shooting accuracy. *Journal of Sports Sciences*, *26*(3), 259-266.

Lou, Y., Abrami, P. C., Spence, J. C., Poulsen, C., Chambers, B., & d'Apollonia, S. (1996). Within-class grouping: A meta-analysis. *Review of Educational Research*, *66*, 423-458.

Lucas, S. R. (1999). *Tracking inequality: Stratification and mobility in American high schools.* New York, NY: Teachers College Press.

McKenzie, T. L., Feldman, H., Woods, S. E., Romero, K. A., Dahlstrom, V., Stone, E. J., Strikmiller, P. K., Williston, J. M., & Harsha, D. W. (1995). Student activity levels and lesson context during third-grade physical education. *Research Quarterly for Exercise and Sport*, *66*, 184-193.

McKenzie, T. L., Marshall, S. J., Sallis, J. F., & Conway, T. L. (2000). Student activity levels, lesson context, and teacher behavior during middle school physical education. *Research Quarterly for Exercise and Sport, 71*, 249-259.

Newell, K. M. (1986). Constraints on the development of coordination. *Motor Development in Children: Aspects of Coordination and Control*, *34*, 341-360.

Oakes, J. (1986). *Keeping track: How schools structure inequality*. New Haven, CT: Yale University Press.

Oliver, K. L., Hamzeh, M., & McCaughtry, N. (2009) "Girly girls can play games" Co-creating a curriculum of possibilities with 5th grade girls. *Journal of Teaching in Physical Education*, *28*, 90-110.

Passos, P., Araújo, D., Davids, K., & Shuttleworth, R. (2008). Manipulating constraints to train decision making in Rugby Union. *International Journal of Sport Science & Coaching*, *3*(1), 125-140.

Pill, S., & Elliott, S. (2015). Effects of Altering the number of players and the dimensions of the playing area on the possession characteristics in youth Australian football. *Sport Science Review*, (3-4), 171-192.

Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport and Exercise Psychology*, *33*, 146-155.

Pinder, R. A., Renshaw, I., & Davids, K. (2009). Information-movement coupling in developing cricketers under changing ecological practice constraints. *Human Movement Science*, *28*(4), 468-479.

Reid, M. I., Clunies-Ross, L. R., Goacher, B., & Vile, C. (1981). Mixed ability teaching: problems and possibilities. *Educational Research*, *24*(1), 3-10.

Rink, J. E. (2006). *Teaching physical education for learning*. (6th ed). New York, NY: McGraw-Hill.

Renshaw, I., Araújo, D., Button, C., Chow, J. Y., Davids, K., & Moy, B. (2015). Why the constraints-led approach is not teaching games for understanding: A clarification. *Physical Education and Sport Pedagogy*, *21*(5), 459-480.

Renshaw, I., Davids, K. W., Shuttleworth, R., & Chow, J. Y. (2009). Insights from ecological psychology and dynamical systems theory can underpin a philosophy of coaching. *International Journal of Sport Psychology*, *40*(4), 540-602.

Renshaw, I., Chow, J., Davids, K., Hammond, J., & Chow, J. Y. (2010). A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis? *Physical Education & Sport Pedagogy*, *9*(2), 1-21.

Rikard, G., & Banville, D. (2006). High school student attitudes about physical education. *Sport, Education and Society*, *11*, 385-400.

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine, 45,* 1273-1284.

Rovegno, I., Nevett, M., Brock, S., & Babiarz, M. (2001). Chapter 7: Teaching and learning basic invasion-game tactics in 4th grade: A descriptive study from situated and constraints theoretical perspectives. *Journal of Teaching in Physical Education*, *20*, 370-388.

Ryan, H. H., & Grecelius, P. (1927). *Ability grouping in the junior high school*. New York, NY: Harcourt, Brace and Company.

Serra-Olivares, J., González-Víllora, S., & García-López, L. M. (2015). Effects of modification of task constraints in 3-versus-3 small- sided soccer games. *South African Journal for Research in Sport, Physical Education and Recreation*, *37*(372), 119-129.

Siedentop, D. (1994). *Sport education: Quality PE through positive sport experiences*. Champaign, IL: Human Kinetics.

Siedentop, D., Hastie, P. A., & van der Mars, H. (2011). *Complete guide to Sport Education*. (2nd ed). Champaign, IL: Human Kinetics.

Silva, P., Aguiar, P., Duarte, R., Davids, K., Araújo, D., & Garganta, J. (2014). Effects of

Pitch size and skill level on tactical behaviours of association football players during small-sided and conditioned games. *International Journal of Sports Science & Coaching*, *9*(5), 993-1006.

Silva, P., Duarte, R., Sampaio, J., Aguiar, P., Davids, K., Araújo, D., & Garganta, J. (2014). Field dimension and skill level constrain team tactical behaviours in small-sided and conditioned games in football. *Journal of Sports Sciences*, *32*(20), 1888-1899.

Silva, P., Travassos, B., Vilar, L., Aguiar, P., Davids, K., Araújo, D., & Garganta, J. (2014). Numerical relations and skill level constrain co-adaptive behaviors of agents in sports teams. *PLoS ONE*, *9*(9), 1-12.

Slavin, R. E. (1987). Ability grouping and student achievement in elementary schools: A best-evidence synthesis. *Review of Educational Research*, *57*, 293-336.

Steenbergen-Hu, S., Makel, M. C., & Olszewski-Kubilius, P. (2016). What one hundred years of research says about the effects of ability grouping and acceleration on K-12 atudents' academic achievement: Findings of two second-order meta-analyses. *Review of Educational Research*, *86*, 849-899.

Tallir, I. B., Lenoir, M., Valcke, M., & Musch. (2007). Do alternative instructional approaches result in different game performance learning outcomes? Authentic assessment in varying game conditions. *International Journal of Sport Psychology* 38(3): 263-282.

Tallir, I. B., Philippaerts, R., Valcke, M., Musch, E., & Lenoir, M. (2012). Learning opportunities in 3 on 3 versus 5 on 5 basketball game play: An application of nonlinear pedagogy. *International Journal of Sport Psychology*, *43*(5), 420-437.

Terwel, J. (2005). Curriculum differentiation: Multiple perspectives and developments in education. *Journal of Curriculum Studies*, *37*, 653-670.

Tieso, C. L. (2003). Ability grouping is not just tracking anymore. *Roeper Review*, *26*(1), 29-36.

Timmerman, E., Water, J. De, Kachel, K., Reid, M., Farrow, D., & Savelsbergh, G. (2015). The effect of equipment scaling on children's sport performance : the case for tennis. *Journal of Sports Sciences*, *33*(10), 1093-1100.

Travassos, B., Araújo, D., Davids, K., Vilar, L., Esteves, P., & Vanda, C. (2012). Informational constraints shape emergent functional behaviours during performance of interceptive actions in team sports. *Psychology of Sport and Exercise*, *13*(2), 216-223.

Travassos, B., Duarte, R., Vilar, L., Davids, K., & Araújo, D. (2012). Practice task design in team sports: Representativeness enhanced by increasing opportunities for action. *Journal of Sports Sciences*, *30*, 1447-1454.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S, Taylor, W. C., Dowda, M., & Sirard, J. (2002) Age and gender differences in objectively measured physical activity in youth. *Medicine & Science in Sports & Exercise, 34*(2), 350-355.

Uehara, L., Button, C., Falcous, M., & Davids, K. (2016). Contextualised skill acquisition research: a new framework to study the development of sport expertise. *Physical Education & Sport Pedagogy*, *21(2),* 153-168.

US Department of Health and Human Services (2010). *Strategies to improve the quality of physical education*. Retrieved from http://www. cdc.gov/HealthyYouth

van der Mars, H. (1989). Observation reliability:Issues and procedures. In P. W. Darst,

D. B. Zakrajsek, & V. H. Mancini (Eds.), *Analyzing Physical Education and Sport Instruction*, (2nd ed., pp. 53-80). Champaign, IL: Human Kinetics.

Vilar, L., Esteves, P. T., Travassos, B., Passos, P., Lago-Peñas, C., & Davids, K. (2014). Varying numbers of players in small-sided soccer games modifies action opportunities during training. *International Journal of Sports Science & Coaching*, *9*(5), 1007-1018.

Wilkinson, S., Penney, D., & Allin, L. (2016). Setting and within-class ability grouping: A survey of practices in physical education Introduction: The policy context of ability grouping in schools in England and Wales. *European Physical Education Review*, *22*(3), 336-354.

Worthy, J. (2010). Only the names have been changed: Ability grouping revisited. *Urban Review*, *42*, 271-295.

Wolpert, D. M., Ghahramani, Z., & Flanagan, J. R. (2001). Perspectives and problems in motor learning. *Trends in Cognitive Sciences*, *5*(11), 487-494.

APPENDIX A

INFORMED CONSENT FOR STUDENTS

AUBURN UNIVERSITY

SCHOOL OF KINESIOLOGY

The Auburn University Institutional Review Board has approved this Document for use from 06/14/2017 to 06/13/2018
Protocol # 17-230 EP 1706

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL ST AMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)
PARENT AL PERMISSION/CONSENT
for a Research Study entitled

"Effects of Homogeneous and Heterogeneous Ability Grouping on Students' Opportunity to Respond, Success Rates, Physical Activity, and Movement Patterns."

Your child is invited to participate in a research study to examine students' participation in a game of over the line ball, similar to ultimate Frisbee. The study is being conducted by, Kurt Ward, and Dr. Peter Hastie of the Auburn University Department of Kinesiology. Your child was selected as a possible participant because he or she is a student in physical education, with Chuck Cooper as the teacher. All fifth grade classes will be participating in a unit of handball. Since your child is age 18 or younger we must have your permission to include him/her in the study.

What will be involved if your child participates? Each of the games will be videotaped using a camera placed next to the play area. If you decide to allow your child to participate in this research study, I am asking for your permission to count the number of times they make contact with the ball during a game, and the degree of their success. No identifying information will be collected other than that record, and I will be the only person who has access to the recordings. When we code your child's game performance, they will not be identified on the score sheet. The videotapes will be destroyed following the conclusion of the study.

Are there any benefits to your child or others? If your child participates in this study, they will help contribute to developing quality physical education programs and better teaching practices for all physical educators.

If you (or your child) change your mind about your child's participation, your child can be withdrawn from the study at any time. Your child's participation is completely voluntary. If you choose to withdraw your child, your child's data can also be withdrawn. Your decision about whether or not to allow your child to participate or to stop participating will not jeopardize you or your child's future relations with Auburn University, or the Department of Kinesiology.

Your child's privacy will be protected. Any information obtained in connection with this study will remain anonymous. The data collected will be protected by Kurt Ward. Information obtained through your child's participation may be used to be published in a professional journal or presented at a professional meeting. However, all these data are whole class data. No individual scores will be used.

If you (or your child) have questions about this study, *please ask them now* or contact Kurt Ward at 208-313-0132 or Doctor Peter Hastie at 334-844-1467. A copy of this document will be given to you to keep.
Parent/ Guardian Initials __ _

If you have questions about your child's rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

Parents/Guardians Initials ____

Participants Initials _____

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH FOR YOUR SON OR DAUGHTER TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO ALLOW HIM OR HER TO PARTICIPATE. YOUR SON'S/DAUGHTER'S SIGNATURE INDICATES HIS/HER WILLINGNESS TO PARTICIPATE.

______________________________ **Participant's signature Date**	______________________________ **Investigator obtaining consent Date**
______________________________ **Printed Name**	______________________________ **Printed Name**
______________________________ **Parent/Guardian Signature Date**	
______________________________ **Printed Name**	

The Auburn University Institutional Review Board has approved this Document for use from
__06/14/2017__ to __06/13/2018__
Protocol # ___17-230 EP 1706___

APPENDIX B

GAME PLAY MAP

Low Skill players are 1-8 with four games in each class

High Skill players are 9-16 with four games in each class

Mixed skilled games have two high and two low skilled players on each team with a total of 8 games in each class.

Black Pinnies key: W = white duct tape, R = red duct tape, B = blue duct tape, and Y = yellow duct tape.

White Pinnies key: R – red duct tape, BK = black duct tape, B = blue duct tape, and G = green duct tape.

Day 1: 9/6/17

Class 1 Day 1 Wednesday 9/6/17 High Skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	13R		9W	11R
10R	14BK		10R	12BK
11B	15B		13B	15B
12Y	16G		14Y	16G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	11R		9W	10R
10R	12BK		11R	12BK
15B	13G		13Y	14B
16Y	14B		15B	16G

Class 2 Day 1 Wednesday 9/6/17 low skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	5R		1W	3R
2R	6BK		2R	4BK
3B	7B		5B	7B
4Y	8G		6Y	8G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	2R
2R	4BK		3R	4BK
7B	5G		5Y	6B
8Y	6B		7B	8G

Class 3 Day 1 Wednesday 9/6/17 mixed skill set 1

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	5R
2R	4BK		2R	6BK
9Y	11B		11Y	13B
10B	12G		12B	14G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	7R		1W	3R
2R	8BK		2R	4BK
13Y	15B		15Y	9B
14B	16G		16B	10G

Day 2 9/7/17

Class 1 Day 2 Thursday 9/7/17 mixed skill set

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	5R
2R	4BK		2R	6BK
9Y	11B		11Y	13B
10B	12G		12B	14G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	7R		1W	3R
2R	8BK		2R	4BK
13Y	15B		15Y	9B
14B	16G		16B	10G

Class 2 Day 2 Thursday 9/7/17 high skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	13R		9W	11R
10R	14BK		10R	12BK
11B	15B		13B	15B
12Y	16G		14Y	16G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	11R		9W	10R
10R	12BK		11R	12BK
15B	13G		13Y	14B
16Y	14B		15B	16G

Class 3 Day 2 Thursday 9/7/17 mixed skill set 2

Game 5			**Game 6**	
Black pinnies	White pinnies		Black pinnies	White pinnies
3W	5R		3W	7R
4R	6BK		4R	8BK
11Y	13B		15Y	11B
12B	14G		16B	12G
Game 7			Game 8	
Black pinnies	White pinnies		Black pinnies	White pinnies
5W	7R		5W	7R
6R	8BK		6R	8Bk
15Y	9B		9Y	13B
16B	10G		10B	14G

Day 3 9/8/17

Class 1 Day 3 Friday 9/8/17 mixed skill set 2

Game 5			**Game 6**	
Black pinnies	White pinnies		Black pinnies	White pinnies
3W	5R		3W	7R
4R	6BK		4R	8BK
11Y	13B		15Y	11B
12B	14G		16B	12G
Game 7			Game 8	
Black pinnies	White pinnies		Black pinnies	White pinnies
5W	7R		5W	7R
6R	8BK		6R	8Bk
15Y	9B		9Y	13B
16B	10G		10B	14G

Class 2 Day 3 Friday 9/8/17 mixed skill set 1

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	5R
2R	4BK		2R	6BK
9Y	11B		11Y	13B
10B	12G		12B	14G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	7R		1W	3R
2R	8BK		2R	4BK
13Y	15B		15Y	9B
14B	16G		16B	10G

Class 3 Day 3 Friday 9/8/17 low skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	5R		1W	3R
2R	6BK		2R	4BK
3B	7B		5B	7B
4Y	8G		6Y	8G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	2R
2R	4BK		3R	4BK
7B	5G		5Y	6B
8Y	6B		7B	8G

Day 4 9/11/17

Class 1 Day 4 Monday 9/11/17 low skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	5R		1W	3R
2R	6BK		2R	4BK
3B	7B		5B	7B
4Y	8G		6Y	8G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
1W	3R		1W	2R
2R	4BK		3R	4BK
7B	5G		5Y	6B
8Y	6B		7B	8G

Class 2 Day 4 Monday 9/11/17 mixed skill set 2

Game 5			**Game 6**	
Black pinnies	White pinnies		Black pinnies	White pinnies
3W	5R		3W	7R
4R	6BK		4R	8BK
11Y	13B		15Y	11B
12B	14G		16B	12G
Game 7			**Game 8**	
Black pinnies	White pinnies		Black pinnies	White pinnies
5W	7R		5W	7R
6R	8BK		6R	8Bk
15Y	9B		9Y	13B
16B	10G		10B	14G

Class 3 Day 4 Monday 9/11/17 high skill

Game 1			**Game 2**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	13R		9W	11R
10R	14BK		10R	12BK
11B	15B		13B	15B
12Y	16G		14Y	16G
Game 3			**Game 4**	
Black pinnies	White pinnies		Black pinnies	White pinnies
9W	11R		9W	10R
10R	12BK		11R	12BK
15B	13G		13Y	14B
16Y	14B		15B	16G

APPENDIX C

GAME PLAY CODING SHEET

Class# Day# game#	sex	Pass S	Pass F	Catch S	Catch F	Targeted	Intercept	Block	ID #
Name									
Team 2									
	all								
	F								
	M								

APPENDIX D

STUDENT MOVEMENT CODING SHEET

	x1	y1	x2	y2	dx	dy	sq	sqrt	abd x	abd y
0	1	3	1	3	0	0	0	0.0	0	0
5	1	3	1	3	0	0	0	0.0	0	0
10	1	3	2	1	1	-2	5	2.2	1	2
15	2	1	3	1	1	0	1	1.0	1	0
20	3	1	3	1	0	0	0	0.0	0	0
25	3	1	1	1	-2	0	4	2.0	2	0
30	1	1	1	2	0	1	1	1.0	0	1
35	1	2	2	2	1	0	1	1.0	1	0
40	2	2	2	1	0	-1	1	1.0	0	1
45	2	1	2	2	0	1	1	1.0	0	1
50	2	2	3	1	1	-1	2	1.4	1	1
55	3	1	3	2	0	1	1	1.0	0	1
1:00	3	2	3	2	0	0	0	0.0	0	0
5	3	2	3	2	0	0	0	0.0	0	0
10	3	2	2	1	-1	-1	2	1.4	1	1
15	2	1	1	1	-1	0	1	1.0	1	0
20	1	1	2	2	1	1	2	1.4	1	1
25	2	2	3	2	1	0	1	1.0	1	0
30	3	2	2	2	-1	0	1	1.0	1	0
35	2	2	2	1	0	-1	1	1.0	0	1
40	2	1	3	2	1	1	2	1.4	1	1
45	3	2	2	2	-1	0	1	1.0	1	0
50	2	2	3	1	1	-1	2	1.4	1	1
55	3	1	3	2	0	1	1	1.0	0	1
2:00	3	2	3	2	0	0	0	0.0	0	0
5	3	2	3	4	0	2	4	2.0	0	2
10	3	4	3	3	0	-1	1	1.0	0	1
15	3	3	2	3	-1	0	1	1.0	1	0
20	2	3	2	2	0	-1	1	1.0	0	1
25	2	2	2	2	0	0	0	0.0	0	0
30	2	2	2	3	0	1	1	1.0	0	1
35	2	3	3	3	1	0	1	1.0	1	0
40	3	3	3	3	0	0	0	0.0	0	0

45	3	3	3	4	0	1	1	1.0	0	1
50	3	4	4	2	1	-2	5	2.2	1	2
55	4	2	3	4	-1	2	5	2.2	1	2
3:00	3	4	2	4	-1	0	1	1.0	1	0
5	2	4	3	1	1	-3	10	3.2	1	3
10	3	1	3	1	0	0	0	0.0	0	0
15	3	1	3	1	0	0	0	0.0	0	0
20	3	1	3	2	0	1	1	1.0	0	1
25	3	2	3	3	0	1	1	1.0	0	1
30	3	3	3	3	0	0	0	0.0	0	0
35	3	3	2	5	-1	2	5	2.2	1	2
40	2	5	3	6	1	1	2	1.4	1	1
45	3	6	2	3	-1	-3	10	3.2	1	3
50	2	3	3	4	1	1	2	1.4	1	1
55	3	4	3	4	0	0	0	0.0	0	0
4:00	3	4	3	4	0	0	0	0.0	0	0
5	3	4	4	6	1	2	5	2.2	1	2
10	4	6	5	6	1	0	1	1.0	1	0
15	5	6	4	4	-1	-2	5	2.2	1	2
20	4	4	3	1	-1	-3	10	3.2	1	3
25	3	1	3	2	0	1	1	1.0	0	1
30	3	2	3	5	0	3	9	3.0	0	3
35	3	5	2	5	-1	0	1	1.0	1	0
40	2	5	2	4	0	-1	1	1.0	0	1
45	2	4	2	2	0	-2	4	2.0	0	2
50	2	2	2	3	0	1	1	1.0	0	1
55	2	3	3	2	1	-1	2	1.4	1	1
5:00	3	2	2	5	-1	3	10	3.2	1	3

APPENDIX E

Data Collection Blue Print

Names	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
Principal investigator	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30
Helper 1		7:45 to 9:30		7:45 to 9:30	7:45 to 9:30
Helper 2	?		?		?
Helper 3	7:45 to 9:30	7:45 to 9:30		7:45 to 9	
Helper 4	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30
Helper 5	7:45 to 9:30	7:45 to 9	7:45 to 9:30	7:45 to 9	
Helper 6	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30
Helper 7		7:45 to 9:30		7:45 to 9:30	
Helper 8	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30	7:45 to 9:30
Helper 9	7:45 to 9:30		7:45 to 9:30		7:45 to 9:30

Monday: 9/4/17

Prep equipment (i.e., tape pinnies with colored duct tape) and have ready to transport out to Pick.

Head over to Pick and Spray paint playing field for 21 by 15 meters with 3-meter end zone within the field.

Equipment to take to Pick:

- Go Pro cameras (check to make sure they are charged)
- Black and white Pinnies
- Colored Duct Tape
- Camera pull
- Copy of game play map for every helper
- Permission slips
- White Spray paint for lines

Equipment at school to be used:

- Cones for end zone markers
- Balls for game play

Tuesday: 9/5/17

Talk to students about the study and how they will be helping me. Ask for student assent by using thumbs up if they want to participate in the study and thumbs down if they don't want to. Make sure students that choice to participate have their parental consent forms turned in.

Either skills test and classification or practice and rules explanation.

Go over the rules with the students using 8 students to play a slow game. After questions and comments are sorted out, split students up and let them play in a game of 4 on 4 just as a practice.

Day 1 Wednesday: 9/6/17

Names	Wednesdays
Principal investigator	7:45 to 9:30
Helper 1	[redacted]
Helper 2	?
Helper 3	[redacted]
Helper 4	7:45 to 9:30
Helper 5	7:45 to 9:30
Helper 6	7:45 to 9:30
Helper 7	[redacted]
Helper 8	7:45 to 9:30
Helper 9	7:45 to 9:30

Day 1, class 1 plan

7:30 to 7:45 Helper 1, and Principal investigator are on Go Pro set up using high jump standard, helper 4 checking filming zone with her computer.

7:45 to 7:50 pinnies set up and prepared for students playing in game 1 (see game play map for names of students playing and pinnies needed) Helper 5 and Principal investigator

7:45 to 8 get Accelerometers sorted and ready for students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:05 to 8:10 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:11 to 8:16 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:17 to 8:22 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:23 to 8:28 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 1, class 2 plan

8:28 to 8:30 Get accelerometers sorted and ready for incoming students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:30 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:35 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:35 to 8:40 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:41 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:41 to 8:46 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:47 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:47 to 8:52 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:53 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:53 to 8:58 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 1, class 3 plan

8:58 to 9:00 Get Accelerometers sorted and ready for students. Principal investigator, Helper 9 Helper 4, Helper 6, and Helper 8

9:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while

Helper 9, Helper 6, and Helper 8 get pennies to students (see game play map for students playing and pinnies needed)

9:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:05 to 9:10 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

9:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:11 to 9:16 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

9:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will

instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:17 to 9:22 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

9:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:23 to 9:28 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 2 Thursday: 9/6/17

Names	Thursdays
Principal investigator	7:45 to 9:30
Helper 1	7:45 to 9:30
Helper 2	[redacted]
Helper 3	7:45 to 9
Helper 4	7:45 to 9:30
Helper 5	7:45 to 9
Helper 6	7:45 to 9:30
Helper 7	7:45 to 9:30
Helper 8	7:45 to 9:30
Helper 9	[redacted]

Day 2, class 1 plan

7:30 to 7:45 Helper 1, and Principal investigator are on Go Pro set up using high jump standard, Helper 4 checking filming zones with computer.

7:45 to 7:50 pinnies set up and prepared for students playing in game 1 (see game play map for names of students playing and pinnies needed) Helper 5, Helper 3, and Principal investigator

7:45 to 8 Get Accelerometers sorted and ready for students. Principal investigator, Helper 7, Helper 4, Helper 6, and Helper 8

8:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 7, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:05 to 8:10 during game one Helper 7, Helper 6 Helper 3, and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will

instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:11 to 8:16 during game two Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:17 to 8:22 during game three Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:23 to 8:28 during game four Helper 7, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 2, class 2 plan

8:28 to 8:30 Get accelerometers sorted and ready for incoming students. Principal investigator, Helper 7, Helper 3, Helper 4, Helper 6, and Helper 8

8:30 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 7, Helper 3, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:35 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:35 to 8:40 during game one Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:41 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:41 to 8:46 during game two Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:47 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:47 to 8:52 during game three Helper 7, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:53 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:53 to 8:58 during game four Helper 7, Helper 3, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 2, class 3 plan

8:58 to 9:00 Get Accelerometers sorted and ready for students. Principal investigator, Helper 7, Helper 3, Helper 4, Helper 6, and Helper 8

9:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, and Principal Investigator, will get accelerometers placed on students while He

Helper 7, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

9:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:05 to 9:10 during game one Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

9:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:11 to 9:16 during game two Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

9:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will

instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:17 to 9:22 during game three Helper 7, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

9:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:23 to 9:28 during game four Helper 7, Helper 3, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 3 Friday 9/7/17

Names	Fridays
Principal investigator	7:45 to 9:30
Helper 1	7:45 to 9:30
Helper 2	?
Helper 3	
Helper 4	7:45 to 9:30
Helper 5	
Helper 6	7:45 to 9:30
Helper 7	
Helper 8	7:45 to 9:30
Helper 9	7:45 to 9:30

Day 3, class 1 plan

7:30 to 7:45 Helper 1, and Principal investigator are on Go Pro set up using high jump standard. Helper 4 checking filming zone with her computer.

7:45 to 7:50 pinnies set up and prepared for students playing in game 1 (see game play map for names of students playing and pinnies needed) Helper 9 and Principal investigator

7:45 to 8 get Accelerometers sorted and ready for students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 9 , and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, and Helper 8 get pinnies to students(see game play map for students playing and pinnies needed)

8:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:05 to 8:10 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will

instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:11 to 8:16 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:17 to 8:22 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:23 to 8:28 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 3, class 2 plan

8:28 to 8:30 Get accelerometers sorted and ready for incoming students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:30 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:35 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:35 to 8:40 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:41 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:41 to 8:46 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:47 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:47 to 8:52 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:53 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:53 to 8:58 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 3, class 3 plan

8:58 to 9:00 Get Accelerometers sorted and ready for students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

9:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

9:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:05 to 9:10 during game one Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

9:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:11 to 9:16 during game two Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

9:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:17 to 9:22 during game three Helper 9, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

9:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 4 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:23 to 9:28 during game four Helper 9, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 4 Monday 9/11/17

Names	Mondays
Principal investigator	7:45 to 9:30
Helper 1	
Helper 2	?
Helper 3	7:45 to 9:30
Helper 4	7:45 to 9:30
Helper 5	7:45 to 9:30
Helper 6	7:45 to 9:30
Helper 7	

Helper 8	7:45 to 9:30
Helper 9	7:45 to 9:30

Day 4, class 1 plan

7:30 to 7:45 Helper 1, and Principal investigator are on Go Pro set up using high jump standard

Helper 4 checking filming zone with computer.

7:45 to 7:50 pinnies set up and prepared for students playing in game 1 (see game play map for names of students playing and pinnies needed) Helper 5, Helper 3, and Principal investigator

7:45 to 8 Get Accelerometers sorted and ready for students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 6, Helper 3, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:05 to 8:10 during game one Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:11 to 8:16 during game two Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:17 to 8:22 during game three Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:23 to 8:28 during game four Helper 9, Helper 3, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 4, class 2 plan

8:28 to 8:30 Get accelerometers sorted and ready for incoming students. Principal investigator, Helper 9, Helper 4, Helper 6, and Helper 8

8:30 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 3, Helper 6, and Helper 8 get pinnies to students (see game play map for students playing and pinnies needed)

8:35 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:35 to 8:40 during game one Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

8:41 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will

instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:41 to 8:46 during game two Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

8:47 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:47 to 8:52 during game three Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

8:53 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

8:53 to 8:58 during game four Helper 9, Helper 3, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Day 4, class 3 plan

8:58 to 9:00 Get Accelerometers sorted and ready for students. Principal investigator, Helper 9, Helper 3, Helper 4, Helper 6, and Helper 8

9:00 as students come in place accelerometers and pinnies on students getting ready to play. Helper 1, Helper 5, and Principal investigator, will get accelerometers placed on students while Helper 9, Helper 3, Helper 6, and Helper 8 get pinnies to students(see game play map for students playing and pinnies needed)

9:05 Game 1 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:05 to 9:10 during game one Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game two (see game play map for students playing and pinnies needed)

9:11 Game 2 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:11 to 9:16 during game two Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game three (see game play map for students playing and pinnies needed)

9:17 Game 3 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:17 to 9:22 during game three Helper 9, Helper 3, Helper 6 and Helper 8 will prep students by getting accelerometers, and colored pinnies on students that are need in game four (see game play map for students playing and pinnies needed)

9:23 Game 4 start: Helper 1 officiates. Principal investigator records game time Helper 5 records time of day when game starts and stops. Principal investigator starts and stops game. Helper 4 will control game play filming from her computer. At the end of each game, I will instruct students that just finished playing to freeze for twenty seconds to help sort accelerometer data during the analysis phase.

9:23 to 9:28 during game four Helper 9, Helper 3, Helper 6, and Helper 8 will prep accelerometers, and colored pinnies to be ready for the incoming students of class two (see game play map for students playing and pinnies needed)

Tuesday 9/12

Back up day if needed

Wednesday 9/13

Back up day if needed

Thursday 9/14

Back up day if needed.