Chapter 3
Fostering Social Connectedness and Interest in Science Through the Use of a Sports Model

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In this study, a group of high school biology teachers collaborated to design instructional units that centrally focused on sports and physical activities. Through action research, the impact of teaching science in this way on students was investigated to inform future implementation. Sports were considered for this purpose as many young people are engaged in sports formally and informally. Formal involvement may include being part of teams and training programs within or out of school. Informal involvement may include playing for fun outside of school, individually or with friends and family. Informal involvement may also include attending sports events or watching sports broadcasts.

Sports have significant potential in creating positive learning environments for students (Giulianotti, 2012). Specifically, sports can support collaboration and team/group solidarity, new social connections, creative self-expression, and active

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A. J. Rodriguez, R. L. Suriel (eds.), *Equity in STEM Education Research*, Sociocultural Explorations of Science Education 26,
https://doi.org/10.1007/978-3-031-08150-7_3

learning. As widespread engagements among students with diverse interests and backgrounds, sports and physical activities can provide students with productive resources upon which educators can build to design engaging and impactful instruction. Such work has been accomplished in science education, across K – 12, whereby students have developed conceptual understanding and scientific skills by learning through sports and physical activities (e.g. Hechter, 2013; Lemaster & Willett, 2019); however, the impact of teaching science through sports and physical activities on students' social gains, particularly social connectedness to their teacher and peers, has been less addressed. The emphasis has remained on (formal) curriculum-defined academic gains as opposed to these gains in social connectedness in and of itself, especially in educational contexts primarily serving students of color.

Some researchers have investigated the impact of social connectedness on motivation and learning. For instance, Ryan and Deci (2000) have focused on *relatedness*, defined as "the need to feel belongingness and connectedness with others" (p. 73). This social connectedness to a learning environment, such as a classroom or subject area, can support students' self-driven desire to participate in learning (Ryan & Deci, 2000). In science education, culturally diverse students, particularly students of color in low-income, urban school settings, have been historically underserved due to a lack of high-quality curriculum and instruction as a result of cultural dynamics and institutional structures in education (Brown & Spang, 2008; Rodriguez, 2015; Thadani et al., 2010). As a result, many culturally diverse students in urban science education may face challenges such as significant gaps or lack of connectedness between themselves and school-sanctioned ways of being scientific or between themselves and their teachers. In classroom contexts where students' perceptions of social connectedness with their instructors were higher, motivation to participate in learning was higher (Hewitt et al., 2019). Additionally, Lin-Siegler et al. (2016) investigated the impact of aiding students to relate more authentically to science, specifically through stories of struggle and overcoming challenges. They found that this was effective in improving motivation and learning, especially for those students who were performing at lower levels, and this was as a result of students' feelings of connectedness to the stories and the scientists who struggled. Conversely, if there is a lack of social connectedness to science and/or science teachers, this may limit students' motivation to engage in science in formal school settings.

Additionally, much of the science education literature reviewing teaching through sports and physical activities has focused on high school and university-level physical sciences (e.g. Starling & Starling, 2017; Widenhorn, 2016), reflective of higher-level science courses and higher-performing, more intrinsically motivated science students. White males of higher socioeconomic backgrounds and higher parental educational backgrounds tend to be overrepresented among students in these areas of science study (National Science Board, 2018). In urban science education, particularly regarding students of color from low-income settings, who have been historically underserved in formal science education, there is great need to work towards improving the quality of science education in more general and introductory science courses, such as biology. Improving these foundational courses may further support a more diverse pool of students in accessing more advanced science courses and post-secondary science study and career participation. This work can, therefore, contribute to extending teaching science through sports and physical activities into other science disciplines, into a wider array of courses, and in ways that are successful for students who are more academically and culturally diverse.

Therefore, this study sought to explore how to build upon the resources of sports, as diverse and widespread engagements, to support social connectedness within a culturally diverse, urban science education setting. To this end, a group of students who had been historically underperforming in science in an urban school setting had the opportunity to learn high school biology through lessons centered on sports. These students were interviewed following these experiences to solicit their perspectives. The focus of the study was gains in social connectedness among students because of learning science through sports and physical activities. Student gains in curriculum-defined knowledge and skills solely or primarily as a result of the sports-focused lessons, distinct from more traditional instruction, were not investigated but will be in future efforts. The choice to focus on social connectedness in the science learning environment, in and of itself, and not on the curriculum-defined learning goals certainly presented challenges to the publication of this research study. The assumption underlying the study's purpose was that, if students are positively engaged and intrinsically motivated, then high quality, deep learning will be supported. This edited book as a venue for this research has provided a unique and timely resource in maintaining this desired study conceptualization and focus.

3.1 Literature Review

3.1.1 Educational Potential of Sports

Sports are particularly effective for education as they are incredibly diverse and widespread, existing globally with all cultures having some local forms of sports (Giulianotti, 2012). Sports are versatile, cost-effective tools for education as they are popular and appealing, especially to young people, with participation ranging from performing to observing (Marshall & Barry, 2015). Many sports can be played with little or no equipment or at minimal cost, requiring only a ball, for instance. Additionally, with formalized school and community sports programs already established within many places and institutions, classroom teaching through sports can build upon these foundations. Thus, as a resource for teaching, sports can be familiar, and easily implemented, and readily relatable to students of diverse interests and backgrounds.

Sports additionally foster social connections and communication among diverse individuals (Giulianotti, 2012; Marshall & Barry, 2015) Therefore, teaching through sports may support students and teachers in developing a socially connected learning environment. When individuals experience social connectedness while engaged in activities, such as classroom teaching and learning, they experience greater motivation (Ryan & Deci, 2000). Additionally, sports can provide students with access to an achievement setting where they have or can develop competence and experience success (Ettekal et al., 2018; Marshall & Barry, 2015). Including opportunities for student growth and accomplishment through sports in the traditional academic setting of the classroom can be particularly beneficial for students who have been disengaged or uninterested in the subject area or for those students who have struggled to learn targeted concepts and skills. With sports serving as the context of instruction and learning experiences, students may feel confident in their sports-related knowledge, interests, and skills and may be more motivated to participate in learning activities. Like social connectedness, these feelings of confidence in one's ability to successfully perform a task increases motivation (Ryan & Deci, 2000).

3.1.2 Science Knowledge and Skills Development Through Sports

Research has reported on science teaching and learning through sports and physical activities. For instance, the fastest score ever made in Junior League rugby served as a physics model for students to learn about aerodynamics and the relationship among factors such as ball size, drag, and athlete speed (Goff & Lipscombe, 2015). Students analyzed the distance that the ball landed after kickoff and the "hang time" of the kick to determine the initial launch speed and angle. Hechter (2013) described an inquiry activity focused on learning about position-position and position-time relationships represented in graphical displays in which students observed and recorded data on the movement of an ice hockey puck when passed by an athlete. Students then generated graphical plots by hand and using technology to represent the motion and positionality of what they observed. They then compared the recorded motion to what they predicted.

From a conceptual change perspective, sports and physical activities can aid in engaging students' naïve scientific conceptions and mental models, thereby helping to overcome barriers to changing flaws in conceptual understanding (Ennis, 2007). Thomas and Quick (2012) discussed where students learned about surface gravity on planets based on relative position in the universe by hitting baseballs with bats and recording the "hang time" of the balls. They calculated the average "hang time" under Earth's gravitational conditions and converted those data to determine the "hang time" on other planets using respective gravitational acceleration data. Playing baseball provided the opportunity to collect meaningful data, which served as a mental model to support the targeted conceptual understanding.

Several other researchers explained how sports "plays" or specific athletic performances within games can be deconstructed and understood in scientific terms.

For instance, Widenhorn (2016) geometrically analyzed 22 attempted penalty kicks in an American soccer game to determine the conditions for which the ball ricocheted off both of the goal posts resulting in failed goals. Starling and Starling (2017) proposed that students can apply scientific understanding and skill to determine the ideal range at which a baseball umpire should stand to make an accurate call about whether or not a baseball player has made it to the base in time. Their analysis focused on real-life data from a professional MLB game and involved multiple physical science variables that would impact the umpire's capacity to make the accurate determination, including the speed of sound and light, index of refraction, and temperature.

3.1.3 Student Social Gains Through Sports

Beyond student gains in science knowledge and skills, efforts in teaching students through sports and physical activities have improved social outcomes for students. This research is well-represented in physical education and sports pedagogy; however, in science education this work appears to be lacking. Garrett and Wrench (2018), for instance, were able to support greater student engagement in dance education for male students from socioeconomically disadvantaged backgrounds. Specifically, efforts were made to improve the inclusion of boys' bodies, interests, and backgrounds in dance classes. By connecting dance to the larger life experiences and interests of male students, they sought to support the expansion of conceptions of masculinity for the young men. Other educators have cultivated positive social behaviors and interactions among students, including respect for peers, good sportsmanship, encouragement and appreciation for others, and active and on-task behavior, through teaching in sports-based contexts (García-López & Gutiérrez, 2015; Samalot-Rivera & Porretta, 2013; Vidoni & Ward, 2009).

3.1.4 Power, Privilege, and Identity in Sport Settings

While there is immense potential to support social gains among students by teaching through sports and physical activities, there exist historical hierarchies and marginalizing ideologies embedded within sports, health, and physical activity contexts. These can be potentially harmful to students' experiences and identity development, counteracting social connectedness and other social gains. Additionally, students' peer interaction in sports-based contexts, like formal classrooms, are vulnerable to the effects of differential power and status and can contribute to privileging or marginalizing students (Brock et al., 2009). Power and status may be influenced by race, ethnicity, income, ability, and other aspects of identity. Therefore, educators must be cognizant of these ideologies and social interactions when teaching through sports and physical activities.

For instance, Tischler and McCaughtry (2011) documented how several male students' masculinities were marginalized as a result of the content, pedagogical practices, student-teacher relationships, and peer social cultures in physical education. Similarly, female students have historically encountered interpersonal and institutional barriers to equitable participation and development in sports and physical education, including feeling "less comfortable" and having negative perceptions of their bodies and physicality (Azzarito & Solmon, 2006); "patriarchal ideologies and patterns of gender differentiation" (Nilges, 1998, pg. 176); and gendered differences in teacher-student interaction within sports/physical education-based settings (Nicaise et al., 2006). Race-based ideologies exist within sports, as well. Black students, especially Black males, are overrepresented in sports (Harper et al., 2013). Furthermore, negative stereotypes about their aggression, athleticism and intellectual inferiority are widespread (Harrison & Lawrence, 2004; Sailes, 1993). Engaging sports and physical activities to teach in culturally diverse settings is a complex and sensitive undertaking, therefore understanding ways to support positive student experiences and social outcomes is of even greater interest to the authors.

Overall, from a review of the literature, research efforts in teaching through sports and physical activities have emphasized gains in student knowledge and skills in advanced physical science courses with student social gains and life sciences being less addressed. These two latter areas are the focus of the current study. A model for pedagogical approach is first presented. This model was implemented with a group of culturally diverse high school students who varied in terms of race, ethnicity, gender, and sport affiliation/involvement. The research question guiding the study was:

> In what ways does teaching biology through sports and physical activities support social connectedness and other social gains among students who are culturally diverse, as well as variably interested and involved in sports?

3.2 Research Context

In 2016–2017, a team of high school biology teachers developed a lesson using basketball to teach aspects of natural selection and adaptation. One teacher was a White male, one was a Middle Eastern male, and two were White females. All were English-speaking and were teaching science for less than 5 years. While the teachers collaborated to develop the lesson, the present study focused on one class taught by the White male science teacher, Mr. Tony. Mr. Tony and all other names in the chapter are pseudonyms. Mr. Tony and one of the female teachers, Ms. Jane, were also part of the research team, along with a Black, English-speaking, Caribbean female as the lead author. The teachers' roles in research focused on the development of the lessons, data analysis, and co-writing. The lead author was active both at the school in which the science lessons were being implemented and at the university, where she worked with a doctoral-level graduate research assistant who identified himself as an African American male.

Mr. Tony's class was one in which students were assigned after having failed previous science classes or having been identified as being behind in grade-level science coursework. Historically, student performance, engagement, and motivation in science in this class tended to be low. Thus, fostering social connectedness through a novel instructional approach may be fruitful in transforming the science learning environment for these students. Action research (Stringer, 2008) supported the authors in systematically collaborating and reflecting on the instructional approach being explored in the high school classroom in order to derive sound understanding to revise and improve the efforts.

The school was located in a medium-sized urban center in the Southeast United States. The school may be, furthermore, characterized as large and culturally diverse. In 2016–2017, 1322 students were enrolled in the school. Enrollment included approximately 42% Black, 36% White, 16% Latinx, 3.2% bi/multiracial, 3% Asian, and 0.3% American Indian or Alaska Native students. Approximately 81% of the students were eligible for free or reduced lunch indicating a high level of representation of lower-income status. Approximately 12% of students were identified as English learners, 13% enrolled in special education, and 12% were experiencing homelessness.

3.2.1 The Instructional Unit: Teaching Natural Selection and Adaptation Through Basketball

The student learning activities took place on a basketball court and later in the classroom. On the basketball court, students engaged in activities to represent a population of organisms in a "basketball" ecosystem. Each individual student represented an organism, while all the students collectively represented the population. In this ecosystem, students would attempt to score baskets, which represented attempts at survival. When students successfully scored baskets, this represented survival of the organisms they modeled. Meanwhile, failed attempts represented death of the organisms. Students all attempted the same type of basket, e.g. a one-handed shot made by jumping near the hoop (i.e. a lay-up), a two-handed throw from an assigned location on the court, or a shot made from the three-point line (semi-circle boundary surrounding the hoop). Multiple hoops were available, so students attempted different kinds of baskets at each hoop. The students attempted the baskets while being variably aided or limited by behavioral and physical factors, e.g. attempting a basket while kneeling (i.e. a physical limitation), while standing on a step-ladder (i.e. a physical aid), or while having the ability to ask a more skilled friend to attempt the basket for them (i.e. a behavioral aid). These behavioral and physical factors or "traits" were randomly assigned to students by drawing cards out of a container. In so doing, traits varied among the students and represented a model of randomized trait diversity among a population as it would in nature. This trait variation was expected to lead to differences in performance (i.e. success or failure in scoring baskets) among individuals in the model population of the basketball ecosystem. The influence of students' skills in playing was recognized as a limitation of the model, i.e. students' own skills in basketball might aid or limit them just as the traits assigned to them; however, this served as an authentic opportunity to discuss with students how scientific models do have limitations in how they represent natural phenomena.

Later instruction built on this activity to explain this trait variation as having been derived from genetic diversity, i.e. the genetic makeup or genes of each organism was different. Additionally, the expression of those genes differed. Gene expression corresponds to what kind of proteins are produced, when, where, and in what combination. Proteins have a multitude of functions relating to structure, function, and performance of organisms. Therefore, diversity in genetic makeup and gene expression influence the physical and behavioral traits of organisms. These traits then influence organisms' chances of survival.

The assigned traits were listed on a class-wide data sheet and the results of students' attempted baskets were recorded as depicted in Fig. 3.1. As above, there are additional limitations important to be understood by both educators and students engaging in this classroom model of evolution. The first important limitation is that this model reflects the unfolding of *survival of the fittest* amongst non-human animals in the wild. While physical and behavioral limitations can severely impact the chances of survival of animals competing to survive in the wild, this does not translate directly to human social systems. While there is a diversity of physical and behavioral characteristics amongst humans, the capacities of humans to adapt challenges a simple analogy of success in one specific task, i.e. scoring baskets, equating to quality of life and survival. This is an important distinction to reinforce to the students as they model these systems.

Relatedly, the second limitation present in this early iteration of the model is the language used to describe the physical and behavioral characteristics. While traits such as size, speed, and senses can affect animals' competitive chances in the wild, amongst humans these traits are not so deterministic. More importantly, diversity in physical and behavioral characteristics within human systems have and continue to be very politically weighted. As such, language used to describe these traits can support or limit efforts towards culturally-responsive and equitable education. Unfortunately, some of the language used to describe the traits modeled in the system is problematic as it bluntly states real human physical traits as disadvantages, e.g. "armless" and "blind." As stated earlier, within human systems, human capacities allow for greater adaptation in response to diverse physical and behavioral characteristics to overcome, rather than be limited by, disadvantages. Thus, this instructional unit did suffer in this earlier iteration from problematic language choice and insufficiently addressing key distinctions between the human systems within which we live and the animal systems being modeled.

A green sticker indicated a successful basket and, therefore, survival; while a pink sticker indicated a failed attempt and, therefore, represented organism death. Students attempted baskets multiple times and, for each attempt, either a pink or green sticker was used to indicate the outcome. After attempting their baskets,

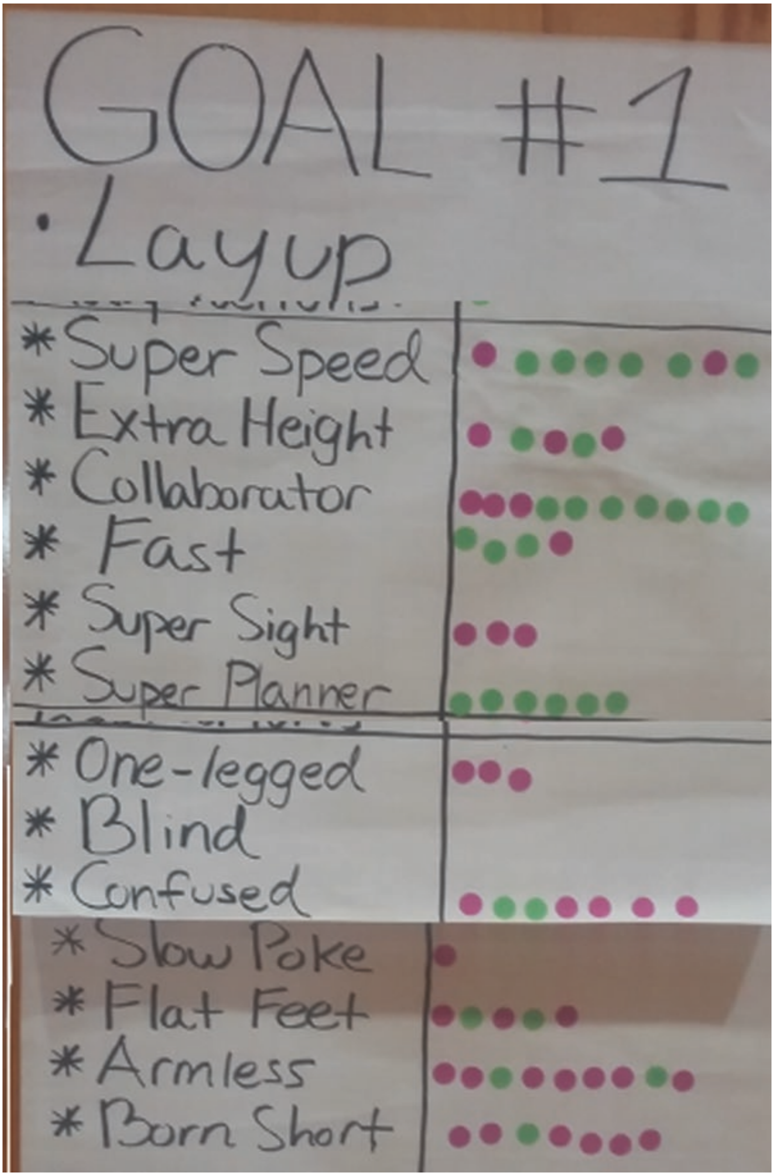

Fig. 3.1 Class-wide data collection

students could then also draw another trait out of the container and attempt baskets differently as required by that trait. After collecting data, but prior to data analysis, Mr. Tony and one collaborating teacher, Mrs. Harriett, structured in an optional activity where students chose to play team basketball with them in teams of three. Mr. Tony and Mrs. Harriett played on a team with one other student and this team played against another team of three students. The students took charge of team selection. After these two teams of three played against each other, several other students participated taking turns forming teams. Other students not interested in this additional game play and physical exertion watched as spectators.

This opportunity to play team basketball was for fun; but the teachers would also later use students' self-selected teams as an analogy for sexual selection. Specifically, the teachers would explain that some students knew who was more or less skilled in basketball or students would look at physical characteristics, such as height, speed, and prior performance in the activities. In trying to choose team members who would likely help them win, these perspectives would have likely influenced students in picking their teams. The teachers explained that that decision-making was analogous to organisms selecting mates for sexual reproduction based on cues indicating which organisms were more attractive, healthy, or fit. As with the earlier discussion of limitations, there are important distinctions between this model of sexual reproduction in animal systems and more complex human social relationships involving personality characteristics (Botwin et al., 1997) and other significantly politically weighted cultural factors (Cellio, 2008). Thus explicit conversations about limitations of the model should take place with students to avoid establishing problematic misconceptions.

Following student data collection, students engaged in analysis by seeking out trends in the data and shared in a whole group setting. Mr. Tony facilitated this whole class sharing out in order to encourage students' first-hand data analysis (rather than the teacher doing the sense-making on behalf of the students). Additionally, by sharing and discussing the data collectively, the teachers and students can confirm accurate student observations of trends and, further, can correct or clarify incorrect observations of trends. This whole group discussion was important to communicate to students that the basketball activity was important scientifically and not just an enjoyable physical engagement, i.e. that their scoring attempts were to aid in their scientific sense-making and that, importantly, the students themselves were all capable of engaging in that scientific skill. Whole group format also supported peer collaboration and students learning by listening to and building off each other's observations.

Following the lesson detailed above, which involved using basketball shooting attempts as a model for adaptation and natural selection, a second lesson focused on biomechanics and American soccer was implemented. For this lesson, the students selectively limited their use of limbs when attempting to kick a soccer ball as far as possible, e.g. maintaining both arms stiffly at their sides and not bending their standing leg when kicking the ball. This lesson helped vividly illustrate for students the interconnectedness of the musculoskeletal system as they came to realize how they engaged so many limbs and body parts in preparing to effectively kick a ball. Previously, the students would focus only on movement involving their kicking leg. As with the optional opportunity to play team basketball with their teachers, Mr. Tony also provided free time to play team soccer with interested students at the end of the lesson.

3.3 Data Collection and Analysis

To investigate the impact of these lessons on fostering social connectedness in this science learning environment, interviews from a sample of students from Mr. Tony's class were conducted and their interview responses were later analyzed. The students represented variable levels of interest and involvement in sport, as well as gender, racial, and ethnic diversity. None of the female participants were interested or involved in sports at the time of the study, while the three males were. This is a recognized limitation of the study, as well as the sample size. Table 3.1 lists the participants, as well as their self-identified race, ethnicity, gender, and affiliation with sport.

Data analyzed were collected in the Spring semester via interviews after the implementation of both lessons. The students were interviewed one-on-one by science teacher candidates who assisted the lead author with data collection. The science teacher candidates included one Latinx female and one White male. Interviews took place in the hallway outside of the students' classroom to provide privacy in sharing responses, while not being too far-removed from their classmates and teacher. The interviews were semi-structured and lasted between 20 and 40 minutes. The interviews focused on student background and past experiences (e.g. What are you interested in doing for work or as a career in the future? How did you become interested in this career?); academic and school history (e.g. How have your experiences been so far in this science class? What do you like or do not like about science class/your science teacher? Do you feel as though you fit in or belong in this class? Why?); students' sense of belonging (e.g. When you were doing sports in science class, did it help you enjoy science class more? Why? When you were doing sports in science class, did it help you fit in better or work better with other students? Why? When you were doing sports in science class, did it help you connect with your teacher? Why? What new things did you learn about your teacher?); and future interest in STEM careers (e.g. When you were doing sports in science class, did it make you more interested in a science, math, engineering, or technology job or career for the future? Why?)

The interviews were recorded, then transcribed verbatim and analyzed thematically (Saldaña, 2015) seeking student responses relevant to the research question, namely social connectedness. Triangulation (Jensen, 2008) for trustworthiness of findings was satisfied via interviewing multiple student participants. In analyzing

Table 3.1 Interviewed High School Biology Students by race, gender and affiliation with sport

Pseudonym	Race/ethnicity	Gender	Affiliation with sport
Nikolas	Native American and White	Male	Actively engaged in sports
Oscar	Latino	Male	Actively engaged in sports
Jonah	White	Male	Actively engaged in sports
Asha	African American	Female	Not engaged in sports
Sophie	White	Female	Not engaged in sports
Liza	White	Female	Not engaged in sports

data and deriving claims, the lead author worked most closely with Mr. Tony, the lead classroom teacher. Member-checking (Jensen, 2008) was used to facilitate this process where the lead author presented questions and developing ideas to Mr. Tony and Ms. Jane who responded, clarified, specified, corrected, or expanded upon these. Insights gained from the implementation of the lessons and the study have guided ongoing revisions and subsequent lessons implemented with additional students, including increasing the clarity with which the sport model was presented and implemented and more explicit modeling in analyzing and interpreting data. These revisions are discussed towards the end of the chapter.

3.4 Findings

Student responses to interview questions revealed the following themes: (i) more enjoyable and beneficial science learning experiences for the students; and (ii) opportunities to foster social connections among the students and between the students and their teacher, Mr. Tony. Additionally, (iii) despite a lack of interest or participation in sports, specific impacts on the female student participants included that learning science in a sports context was effective for them and they were able to explain these processes in their own words. For one female African American student, this science learning experience reinforced her pre-existing motivation to pursue a nursing career.

3.4.1 More Enjoyable and Beneficial Science Learning Experiences

Some students explained that integrating sports into science made the learning process more enjoyable and successful because it connected to their out of school interests. Even for students who were not typically engaged in sports outside of school, learning science through sports was simply fun and provided opportunities to be more actively engaged in learning as opposed to passively listening to their teacher. When asked, "Have you enjoyed learning using sports? Why was that?", Nikolas, a Native American and White male engaged in sports shared that:

> ... out of school, I like to play sports. So, learning in a way that I like, that's enjoyable for me, helps me concentrate and enjoy because if you don't enjoy something, you're bored. And if you're bored, you don't pay attention. You don't comprehend what is happening.... I play sports outside of school a lot.

Similarly, when responding to the same question, Oscar, a Latinx male often engaged in sports, shared that "[Playing sports to help me learn science is]... more fun. I like playing soccer." Both young men acknowledged that they enjoy sports and participate in sports outside of school. The sports context of the science lessons aligned with these students' preexisting interests out of school. Nikolas, in his response above, went on to discuss the important correlations between interests, engagement, and learning. Additional enjoyable features of the sports units for students included the opportunity for active engagement in order to learn science. Jonah, a White male engaged in sports, explained:

> [Playing sports to help me learn science was enjoyable]... Yes.... Because you got to do something active and such. It's a lot, it makes classes a lot more fun when you get to actually get up and do something.... I'm normally that kind of person who really does sports... When I do them, I'm *into* them....

When asked in a follow-up question, "Did you look forward to coming to science class?", Jonah stated, "Yes.... I really like this class. It makes it fun...." , indicating an enhanced interest in science class.

The female participants were not engaged or interested in sports prior to these lessons. Despite this, they similarly explained that science class was more active and enjoyable and, as a result, more beneficial to their learning when taught in a sports context as opposed to a passive, teacher-centered learning environment. When asked if her teacher's instructional approach to use sports to teach science was helpful, Asha, an African American female student, explained that "It's more hands-on than just sitting there and listening.... Because you got to enjoy different things and then like you got to have fun while also doing school work." Similar to her classmates, Asha also agreed that this approach engaged her interests in class more effectively and that she believes that she was able to learn more successfully. Asha stated, "... because class is boring.... I feel like I learn better with doing sports...." Sophie, a White female, also explained that playing sports to help her learn science was enjoyable "... because it was more hands-on rather than just sitting in the class like listening to a lecture."

3.4.2 Opportunities to Foster Social Connections

In designing the basketball lesson, the teachers structured in an opportunity for students to play team basketball, which involved the students and two teachers playing against each other in teams of three. Similarly, in the soccer lesson, students had the opportunity to play against each other in teams for friendly competition. These opportunities to play in teams helped foster social connections, even among students who did not know each other well before. Students were asked, "When you were doing sports in class, did it help you fit in better or work better with other students?" They discussed how this team structure supported a more personal and friendly learning environment. Sophie explained that "... because we had to have teamwork when we were playing soccer.... I actually didn't know a large percentage of this class until we played soccer and I met them.... It was more like personal and interactive...." Nikolas similarly explained that he was better able to fit in and work with other students, "... because we were on teams. So, we had to work with our teammates." Asha also agreed that structured opportunities for teamwork in the sports context helped her fit in and work better with her classmates, despite her not previously enjoying collaborating with others: “Yes.... because I don’t like working with other people. [So, it] helped a lot. ...” Asha went further to explain that not only did she enjoy working other classmates, but she also made new friends while participating in the sports-focused science lessons: “Yes. I got to make more friends and I got to know a lot about more people in the science class.”

Beyond experiences of greater social connectedness among students, some students discussed the impact of these lessons on their relationship with their science teacher, Mr. Tony, stating that they learned more about him and cultivated a more personal relationship with him. Oscar explained “... because I was playing with my teacher and [classmates] and got to know them better. [For instance, I]... learned what sport they [my classmates] liked. Like they liked soccer. [I learned that my teacher]. .. likes soccer and he likes sports.”

Sophie also commented about her new insights about her teacher: “[I learned]... just how outgoing he is.... Yeah he really is [good at soccer]!” Jonah and Nikolas discussed how they appreciated Mr. Tony as a teacher. Jonah enthusiastically described his relationship with Mr. Tony and how Mr. Tony balances fun with seriousness in learning: “... the teacher-student buddy thing.... you’re really friends with that one teacher and next year, you’re like, “Hey.” I got that.... He [my teacher] is really fun and serious sometimes.... Like, at times he gets kind of scary-serious. It’s amazing!” Nikolas indicated that he recognized the effort that Mr. Tony put forth in designing instruction around their interests: “Yeah.... Because he actually knows what we like to do, what we all like to do and he picked it [basketball], so, because we liked to do it.”

3.4.3 Specific Impacts on Female Student Participants

None of the female students were engaged in sports nor indicated that they enjoyed sports. Despite this, they each reflected on why the process of learning the targeted scientific concepts through engagement in sports was beneficial to them, beyond enjoyment. In other words, they were able to explain how learning through sports helped them learn the content better. They were not interested in learning activities that were simply fun and active. When asked if the lessons made science class more enjoyable, Liza, a White female student, agreed, but quickly explained that the sports, in and of itself, was not what made it valuable for her. Rather, she explained how learning by being immersed in sports supported her in learning the concepts more effectively:

> It did [make science class more enjoyable]. I mean, I thought it was a good opportunity but I—I wasn’t really interested in it because you were—I don’t like basketball first of all. Basketball is just not a thing for me.... But I think it was like, it was helpful to see how things and like what you can do.... Like in the situation or in the adaptations you were given.... Because it like—one-on-one interaction. You got to go do it and see how it [the scientific phenomenon of an organism surviving or dying] works. Like, it’s not just like shown to you [by the teacher or in a textbook]—you’re doing it.

The activity of attempting baskets under variable conditions served as a concrete model for Liza to understand how organisms are variably at an advantage or disadvantage for survival. This embodied process of learning by "doing it" was a more effective way for her to learn as opposed to attempting to understand the concept by the teacher explaining or presenting it. The ways in which the female students discussed their experiences in the lessons underscores that the sports-based activities were educative and not used as fun classroom management "hooks" or gimmicks. Similar to Liza, Sophie explained why this learning experience was effective for her:

> Because if we're like playing a sport outside of school, we're not like actually with the learning aspect and we were [learning in this case].... I actually felt the muscles we were talking about [in the biomechanics unit] like working which really made a difference.

Asha was the third female participant. Similarly, despite a lack of interest and engagement in sports, in and of themselves, this means of science engagement supported her in connecting what she was learning to future science career interests that she had already established.

> ... you got to see different movements – how the body works, how the bones—like how your body moves.... It made me really want to become a nurse now.... [because, in the biomechanics unit,] you got to learn the parts in the body and how they work and how they move.

These impacts of in-class science teaching and learning aligning with Asha's science-related career interests would be important in reinforcing and sustaining these interests over time.

Overall, social gains among students as a result of learning biology embedded in the described sports and physical activities context included benefiting from a more enjoyable and engaging science learning environment, learning more about peers and their science teacher, fostering meaningful connections to their teacher and new connections to peers, reflecting on future science-related career plans, and thinking metacognitively about how the instructional unit supported them in learning the material.

3.5 Discussion

This study sought to explore the ways in which teaching biology through sports and physical activities supported social connectedness and other social gains among students who were culturally diverse, as well as variably interested and involved in sports. First, a model for teaching biology through sports and physical activities was presented to expand this pedagogical approach beyond advanced physical science and to support positive social gains among students. Furthermore, the model was implemented with a group of culturally diverse high school students who varied in terms of race, ethnicity, gender, and sport involvement. Teaching science through sports and physical activities had the effect of making the science learning experiences more enjoyable and beneficial for the students, as well as supported social gains, particularly social connectedness between the students and their peers, their teacher, and learning science. The female students also articulated the ways in which the sports activities facilitated their understanding of the targeted content. Gains for the female students interviewed were comparable to the males interviewed, as well as between the selected students who were more and less interested in sports. This was encouraging given research that indicates the potential to marginalize students in sports contexts due to these differences.

When seeking to implement more culturally inclusive pedagogy, teachers must be aware of the social, historical, and institutional contexts to which the ideas underlying instruction are connected as these can evoke both positive or negative experiences and emotions for students (Rodriguez, 2017). In regards to teaching science through sports, important concerns included the potential of biasing students who enjoyed sports and were more involved or skilled in sports (Grimminger, 2013). Similarly, there were concerns about marginalizing students based on ability or able-bodiness (Sato & Haegele, 2017), as well as biasing male students over female students based on ideologies regarding body image, skills, gender, and other social factors (Azzarito & Solmon, 2006; Brock et al., 2009; Garrett & Wrench, 2018; Nicaise et al., 2006; Nilges, 1998; Tischler & McCaughtry, 2011). Additionally, Black students, especially Black males, are challenged by prejudicial ideologies that emphasize physicality over intellectual capacity (Harper et al., 2013; Harrison & Lawrence, 2004; Sailes, 1993). Engaging in sports in order to learn can, therefore, be an empowering, prideful, and positive experience for students, but it can also potentially be risky, shameful, or dehumanizing. Additionally, one reviewer of this work raised questions regarding the appropriateness of modeling sexual reproduction via teams involving students and teachers and the potential of triggering negative emotions and experiences amongst students. Within the context of this work, the teachers and students exhibited positive connections and rapport. Additionally, the activity in which students and teachers formed teams was optional and the students led the team selection; however, many negative reactions can take place silently and beneath the surface (Mark, 2021). Thus, this guidance is taken seriously and will inform future pedagogical efforts to ensure that no students are made to feel uncomfortable. Again, a major concern when implementing this work has been awareness of social, historical, and institutional contexts.

Rodriguez (2017) advocates for teachers to be supported in developing critical emotional pedagogy and other proficiencies in order to understand the contexts within which these emotions can develop and to gain practical skills in designing instruction to cultivate a positive social experience for students. While this perspective did not inform the design of the lessons, there was some evidence of alignment to these important considerations. None of the participants in the study discussed feelings of embarrassment, negative peer perception, or any kind of ridicule or stereotyping despite being varied in terms of athletic interest and skill, as well as racial, ethnic, and gender identity. From observations of the lessons being implemented, students depicted high levels of engagement and enjoyment. There were lots of cheers and sustained attention throughout the physical activities components of the units. These lessons have remained highly popular and anticipated among subsequent students. These positive outcomes were likely due to the teachers' instructional design by which, of focus, were sports activities, as opposed to win-lose competition. In attempting baskets, students were randomly assigned traits that would aid or hinder them to a greater degree than natural skills. In other words, students were focused on the effects of the physical and behavioral traits that they modeled rather than their natural abilities to successfully score baskets. Students were never singled out or intentionally selected by teachers to perform, demonstrate, or opt-out of a physical activity. While the students themselves were not made to feel inferior, as discussed earlier, greater caution will be taken to directly address important differences between animal and human systems in the ways in which physical and behavioral limitations and survival of the fittest operate. While physical and behavioral limitations can be significantly disadvantageous and threatening to the survival of animals in the wild, humans have greater capacities to adapt, as well as are more driven to be inclusive to people of diverse abilities and characteristics. It will be important to have these conversations before and/or after modeling the systems with students.

Furthermore, the opportunity to play team basketball, which was more competition-oriented, was optional for students. Only interested students participated, thereby reducing any feelings of unease. Yet still, the process of choosing teams was connected to targeted content and, therefore, still educative. Although all students did not play, all students watched and the teachers referred back to the process of team selection during whole-class discussion following the activity to make analogous connections to sexual selection. In light of these concerns, findings indicating positive gains in social connectedness among peers and with the teacher for both male and female students and students ranging in sports interest and skill are very encouraging. These indications are especially encouraging for the female participants who explained that they were not interested in or disliked sports, but yet felt positive feelings of social connectedness to their male science teacher and their peers in the context of playing sports.

None of the female participants were engaged in sports nor indicated that they enjoyed sports; however, they articulated the ways in which learning science through sports was effective for them, beyond making class and learning more enjoyable. This finding was consistent with previous research in which, through focus groups, female science students showed that they actively reflected on instructional strategies that supported them in learning science deeply (Buck & Ehlers, 2002). Specifically, the female students expressed a desire for more hands-on and active learning, but not for fun; rather they believed that these instructional approaches would provide them with more concrete ways of understanding the content beyond reading and note-taking. They further critiqued learning experiences when they were asked to complete hands-on activities with limited explanation of how it was connected to targeted content by their teachers.

As teachers prepare to utilize sports and physical activities as instructional resources, the diverse needs and interests of all students in the classroom must be considered. As the data indicated, even students usually uninterested in sports may enjoy and benefit from learning through sports; however, for students uninterested in or resistant to learning through sports or physical activities, such lessons may not best serve as learning activities as they may become impediments to equitable learning opportunities for all students. Rather, sports-based lessons can be offered as one of several varied options, including those not involving sport and physical activity; but all targeting the same student learning goals. Student choice can then be allowed where interested students can choose to participate in the sports-based lessons. This supports differentiation in instructional design and student choice, which are both best practices in equitable teaching and learning (Brown-Jeffy & Cooper, 2011; Buck & Ehlers, 2002).

3.6 Limitations and Future Research

There are a number of limitations to consider when implementing action research (Stringer, 2008). Action research can be limited by focusing on driving questions and issues specific to particular contexts and, thus, limiting its transferability. The effectiveness of sports as a framework for science teaching may be specific to this community of students and their teachers, however, cultivating social connectedness through intentional instructional design is a broadly compelling goal to enhance the science educational experiences for groups of students in other settings. Additional limitations of action research include the personal nature of the research context in which teachers collaborate with researchers to investigate themselves and their own teaching practices. The researchers are limited, as well, in investigating the practices of individuals with whom a familiar relationship has been cultivated. While these are acknowledged limitations, the outcomes of action research are much more beneficial to the community in which the research has been conducted as the teachers have developed expert knowledge to be utilized in ongoing practice with the same or future students.

The study was also limited in terms of focusing data analysis on a few students as opposed to a larger data set, as well as interviewing students about their teacher at the time and his teaching practice; however, this approach was used to analyze open-ended, qualitative responses to support deep understanding from students' perspectives. Among a larger data set, the effectiveness of this pedagogical approach for students is expected to vary; however, determining successful strategies for some students, even if not all, is still an advancement as the approach of teaching science within sports contexts adds to the collective set of strategies available for educators. Informed by this study focused on sports as a framework, social connectedness may be targeted by utilization of other frames, including arts-integration, social justice, and global citizenship, as examples.

Additionally, if, instead of interviewing students, data analysis focused on the teachers' perspectives only or effectiveness defined in terms of students' academic gains on content-based assessments, then this would fail to capture necessary insights of the students' social experiences during learning. Future research would aim to gain understanding of impact from larger numbers of students. Additionally, the purpose of the study was to investigate social impacts. As stated earlier, student gains in targeted knowledge and skills solely or primarily as a result of the sports-focused lessons, distinct from more traditional instruction, was not investigated and will be in future efforts.

3.7 Data-Informed Development of the Biology Lessons Over Time

The original purpose of these lessons, specifically those that integrated basketball, was two-fold. The first was to create engagement in science through movement and physical activity. The second was to model a concept of change over time that the team of high school biology teachers believed would be difficult for their students to understand and explain as some aspects of natural selection and adaptation are not readily discerned from a reading. There were some initial limitations, namely some instances of lack of clarity and connections to the targeted concepts, as well as students' limited analysis of data. Despite these limitations, the design and implementation of basketball game play as an instructional model served to aid students in explaining the phenomenon of Darwin's theory of natural selection in a relevant and time-condensed manner and did advance learning goals among this group of students, even if more modest in the first iteration. Through basketball game play, students benefited from first hand experience of a process reflective of survival based on the fitness of specific traits, thereby providing them intimate knowledge of a process of change and adaptation that takes hundreds of years to develop.

The first year this lesson was implemented, many challenges in comprehending the content standard and the scientific practice of arguing from evidence were still present among students; however, there was the strong, immediate connection between students and teachers, as well as among students. This social connectedness supported an important cultural shift in the classroom community as the students now saw their teachers as, not only experts in teaching, but as social, interesting, and invested partners in their learning. From assessment data not included as part of this study, there was an increase in students' test scores in this newly implemented unit centered on sports and physical activity compared to prior forms of instruction, but this increase was not as large as the teachers anticipated.

Subsequently, a number of changes were implemented hoping to improve upon the model driven, in particular, by an emphasis on high yield practices of teacher clarity and student-teacher relationships (Hattie & Zierer, 2017). Changes included the teachers modeling the activities for students prior to the students implementing the activities themselves and more clearly explaining the conceptual ideas underlying natural selection. The teachers also displayed and utilized the data in more effective ways. Specifically, in the first iteration, data were collected and displayed nearby to each basketball game play station, but during subsequent iterations, the teachers more intentionally focused students' attention back to the data displayed and more continually emphasized and modeled the analysis and interpretation of these graphical data. Students reflected on the data and made interpretations in writing in order to derive reasons for variation of traits, competition, advantages of species possessing certain traits, and to explain why species that possess certain traits were more likely to survive and reproduce. The data also illustrated the counterintuitive randomness of selection by the fact that 'advantageous' traits did not always help organisms succeed. From school-based assessment data, not included in this study, these changes led to increases in student mastery (as defined by state assessment standards) of the scientific practice of analysis and interpretation of data in both formative assessments and state-level testing. Even more, for each successive iteration of the lesson, according to the teacher team, there was growth beyond the previous year for students in regards to this measure of proficiency for this scientific practice based on both the teachers' formative assessments and state-level accountability measures (State Department of Education Assessment Data, n.d.). No validity measures were conducted against the teacher team's claims, however. This is a recognized limitation and will be conducted in future investigations.

Other improvements in the lesson included that students who were willing to challenge other students or teachers in the team competition aspect of the lessons were later asked to complete a separate reflection that focused on the reasoning underlying their choices of teammates and the result of the team challenges. This written reflection was far more specific than previous years where the team competition aspects were debriefed only verbally in a whole-group setting. The students' written reflections on this aspect of learning provided resources that added to the verbal, whole-class discussion, which helped support greater student understanding of natural selection versus sexual selection. Additionally, an alternative assignment was provided as an option for those students who did not want to participate, or could not, in the physical activities. This assignment required students to make detailed observations and record data for the student-centered sport model being implemented, as well as for other species going through natural selection and sexual selection.

The most consequential outcome of the lessons was that both students who participated in the lessons directly, as well as those who only indirectly heard about it from other students, regarded the learning experiences as successful such that future classes began asking if this was a lesson *they* would get to participate in and when it would occur. Success from these students' perspectives, in addition to the interview data provided, meant that the learning experiences were engaging, productive for their learning about scientific concepts and phenomena, and, importantly, socially connected. These classes became a social and cultural context in which students wanted to participate and looked to with anticipation.

3.8 Conclusions

This research was supported by University of Louisville, College of Education and Human Development Research and Faculty Development grant funding. The goal of this internal grant was to support pre-tenure faculty at the institution in

conducting smaller-scale pilot research to bolster future efforts towards acquiring larger, external grant funding. The main barrier to disseminating this work centered on efforts to publish. The researchers acknowledge that earlier drafts of the manuscript were in need of revision and substantial revisions have been completed; however, all but one of these decisions did not invite resubmission. Oftentimes, criticisms of the work centered on the lack of attention to measurable gains in students' academic achievement and cognitive processing as a direct result of these lessons. The challenges here were at least two-fold. First, the study sought to examine social connectedness as a necessary factor in supporting academic gains. Second, the educational and social contexts of the students' academic performances included many challenges that might not be necessarily overcome with the implementation of these lessons alone; however, significant enhancements to the students' learning environments might have been achieved as a result of these lessons, namely greater interest and social connectedness regarding science education and career development, that might also persist well beyond the study.

What is being argued in this chapter is an important focus on the quality of students' learning environments, including students' emotions and social contexts, even if students do not make statistically significant gains in content-focused post-assessments. While dismissing the pedagogical efforts discussed in this study as insufficient to be effective in elevating this group of students' academic performances, some of these critiques also dismissed the role of significant educational and social inequities in interpreting the academic performances of the students. For students who have historically experienced school science as uninteresting and alienating, gains in social connectedness, as a potential precursor for long-term academic and career interests in science, are argued as significant and attributable to this team of teachers and their pedagogical efforts in developing and implementing the sports-focused biology lessons.

Acknowledgements This work was supported by Matt Trzaskus and Lauren Archer as science teachers, their science teacher colleagues, and their students. The authors are additionally grateful to Lorena Gonzalez Velazquez, Abigail Sheeran, Phillip McCauley, as well as to earlier reviewers of this manuscript and their thoughtful feedback that has enhanced the work.

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